Unveiling Venus • Summer's Best Star Parties

ASTRONOMY®

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ICD 08070

Ultimate Color: Catch it on Film

A Star is Born

- Collecting Space Rocks
- Astronomy at the South Pole

LX50

Advanced technology at the most affordable prices *ever.*

■ **Battery-Powered, Completely Cordless Operation!** Meade LX50 models operate for more than 50 hours from six AA-size batteries inserted through the telescope's control panel. Or use the standard-equipment 25 ft. cord to power the telescope directly from any auto cigarette lighter plug.

■ **Standard-Equipment Declination Motor and Hand Controller:** Plug the hand controller into the LX50 control panel and you're ready for full dual-axis drive capability at any of 4 photo-guide or microslew speeds: 2x, 8x, 16x, or 32x, plus quartz-controlled sidereal-rate tracking in R.A. Switch speeds instantly using the speed-control button on the hand controller. Dual-axis drive rate is indicated by a red LED.

■ **Multi-Function Control Panel:** Includes connectors for CCD autoguiders; for the standard-equipment Declination motor; and for the optional Magellan II Computer-Corrector *(below).* A North-South switch permits telescope operation anywhere in the world.

■ **Super Multi-Coated Optics:** The exact same EMC super multi-coated optical tube assemblies included with Meade LX200 models.

■ **Massive LX200-type Fork Mounts:** Meade LX50 mounts are manufactured of the same virgin aluminum castings as Meade LX200 Schmidt-Cassegrains. Massive, rigid mountings that include the Meade LX worm-gear drive system with low periodic error for advanced photographic or CCD imaging applications. *No competing mid-priced equatorial mountings even come close.*

SPECIFICATIONS: 7", 8", and 10" LX50's—Each complete telescope includes 8" or 10" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty LX200-type fork mount; 5.75" LX worm gear system in R.A.; multi-function control panel; DC servo Declination motor; manual and electric slow-motion controls on both axes; setting circles on both axes; keypad hand controller; 4-speed drive controls on both axes; battery compartment accepting six (user-supplied) AA-size batteries; 25 ft. power cord for telescope operation from 12v. auto cigarette lighter plug; 6 x 30mm (7" and 8" models) or 8 x 50mm (10") viewfinder; 1.25" diagonal prism; MA25mm multi-coated eyepiece (1.25"); standard equatorial wedge with elevation scale, bubble level, and azimuth control; complete operating instructions.

8" LX50 Schmidt-Cassegrain	**$1395.**
10" LX50 Schmidt-Cassegrain	**1695.**
7" LX50 Maksutov-Cassegrain	**1795.**
Variable-Height Field Tripod	**295.**
7" Maksutov-Cassegrain Tube Ass'y	**1295.**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 7"—$125; 7" Tube Assembly—$65.

Meade Magellan™ II Computer-Corrector for LX50 Telescopes: Plug the Magellan II into the control panel of your LX50 and enjoy an incredible range of advanced capabilities. ■ Fast manual slewing to any object, either from input RA and Dec or from the 12,218-object database. ■ High-resolution 4096-pulse encoders (5.3 arc-minute precision), concealed in special LX50 encoder compartments. ■ Large 32-character, red-backlighted display. ■ Quick 2-star alignment. ■ Four-speed (2x, 8x, 16x, 32x sidereal) dual-axis drive corrector/microslewing system.

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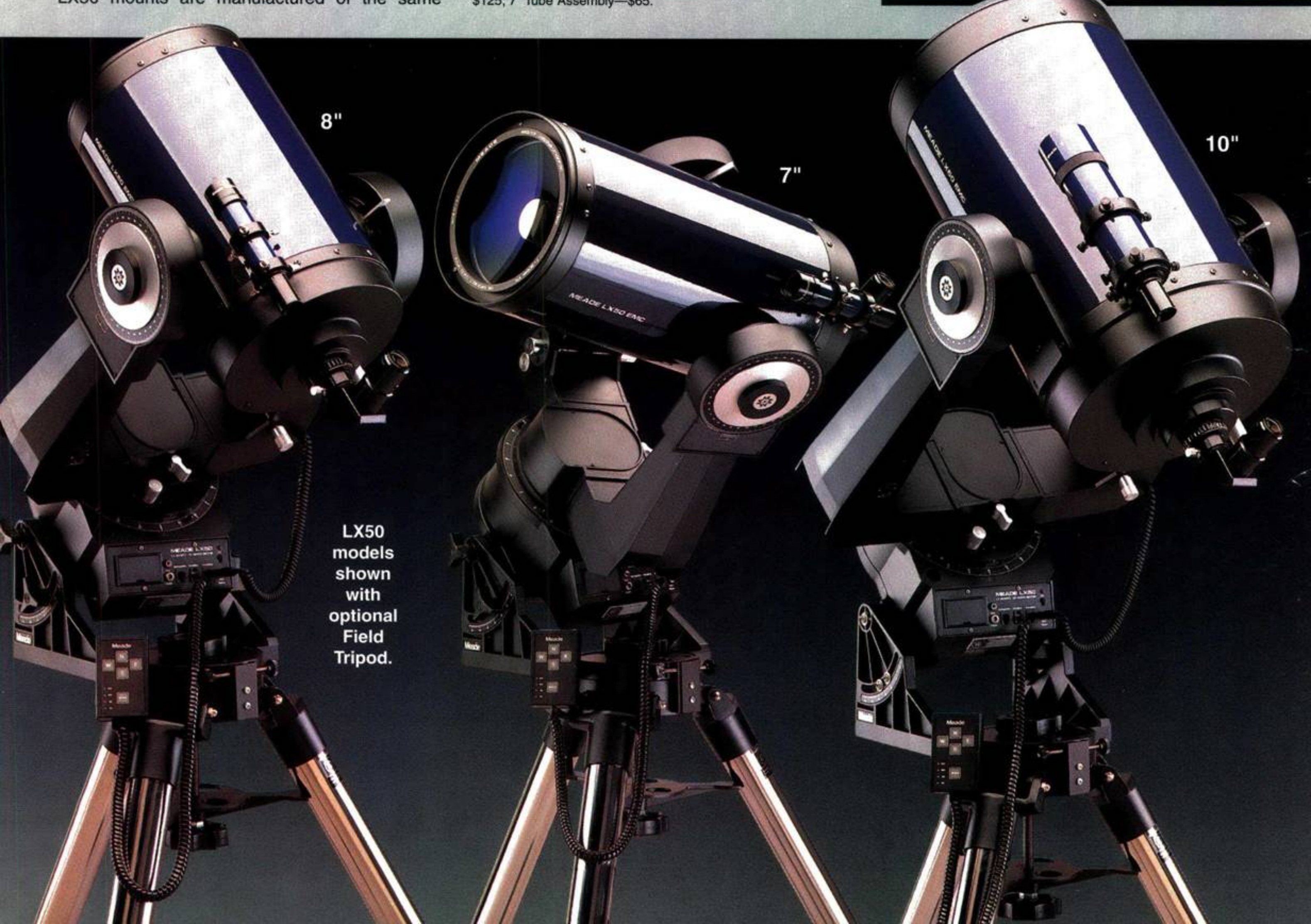
#2024: Magellan II for LX50's—Includes Magellan II hand controller *(right)*; encoders for both axes; all required mounting hardware. Installs to any LX50 in minutes. **$495.** + $15 packing and shipping in the 48 states.



LX50 models shown with optional Field Tripod.

ADE

The largest-selling serious telescopes in the world.

LX200

In virtually every country in the world where serious telescopes are sold, more Meade LX200's are sold than all competing models *combined*. Consider these *standard-equipment* specifications:

- **Superb Optics:** LX200 diffraction-limited imaging capabilities are a legend in the industry; we regularly receive reports stating that optical performance approaches that of a fine *ED* apochromatic lens.

- **Automatic GO TO Capability:** Meade LX200's are *the only commercial telescopes ever manufactured* that automatically GO TO any input R.A. and Dec., or to any of 64,359 objects in the onboard database, *to a precision of one arc-minute or better.*

- **Meade LX200 High-Precision Pointing**™ is so precise it permits the positioning of *every* selected object on *every* commercially-available CCD chip *every* time, automatically — *a feat that no other telescope priced under $40,000 can accomplish.*

- **Permanently-Programmable Smart Drive**™ routinely achieves 5 arc. sec. periodic error, an observatory standard.

- **9-Speed Dual-Axis Electronics:** Electronics that cover every possible contingency of telescope positioning—from 2x photo-guide, to 32x image centering, to 8°/sec. slewing across the sky, as well as 6 other dual-axis drive speeds in between.

- **Field Operation:** No other telescopes of such incredible capabilities transport so readily for field operation. The optional #1812 Electronic DC Adapter (a compact 4 oz. unit) allows for field powering directly from an automobile cigarette lighter plug.

SPECIFICATIONS: 7", 8", 10", and 12" LX200's—Each complete telescope includes 8" or 10" (f/6.3 or f/10) or 12" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty fork mount with 4" polar ball bearing, dual-axis 5.75" worm gears, and multi-function control panel; manual and electric slow-motion controls on both axes; keypad hand controller with digital readout display, permanently programmable Smart Drive, 9-speed drive controls on both axes (7-speed on 12"), High-Precision Pointing, and GO TO controller; 64,359-object onboard celestial software library; 25 ft. power cord and adapter for telescope operation from 115v.AC; 8 x 50mm viewfinder; 1.25" diagonal prism (7", 8", 10") or 2" diagonal mirror with 1.25" adapter (12"); Series 4000 Super Plössl 26mm eyepiece; standard field tripod (7", 8", 10") or giant field tripod (12"); operating instructions.

8" LX200 Schmidt-Cassegrain	**$2795.**
10" LX200 Schmidt-Cassegrain	**3195.**
12" LX200 Schmidt-Cassegrain	**4495.**
7" LX200 Maksutov-Cassegrain	**3295.**

Packing and shipping in the 48 states:
8"—$105; 10"—$145; 12"—$215;
7"—$125.

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At the Heart of the Lagoon

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Cover art
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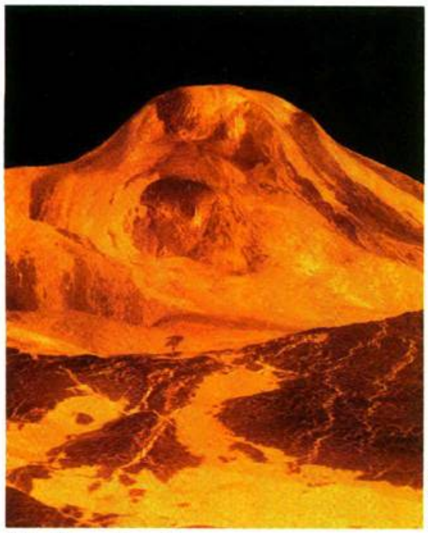
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BEHIND THE SCENES

Going Way South

When you stand at the South Pole, you're standing on a two-mile-deep pile of ice and snow. This is desert territory; only a few inches of snow fall here each year. But the snow never melts and the pile just gets bigger. Top that off with a six-month night and you get some idea about why very little human action occurs at the pole.

A decade ago, though, astronomers got serious about using the South Pole for research, mainly because the skies there are extremely clear and the nights so long. To do this, researchers developed unusual ways of building things — like putting instruments on stilts — and unusual methods of doing science — like carving telescopes out of the ice. To get a good look at their work, writer Beth Livermore visited the South Pole in January 1996. How she turned that trip into "Going to Extremes" (page 52) for ASTRONOMY is a rather unusual story in itself.

Beth Livermore

Writer Beth Livermore emerges from the igloo she slept in as part of her Antarctica survival training.

In 1995, Beth asked me for an assignment that would take her to Antarctica. I was working at an ocean sciences magazine, and agreed to give her a story about that mysterious zone of mixed seawater at the edges of the Antarctic. Journalists gain entry to U.S. research stations in Antarctica only through the National Science Foundation, which also gives them some travel support and survival training.

The NSF agreed that Beth should visit, and so she did. Meanwhile, the ocean sciences magazine stopped publishing before we could run her story, and I became the editor of ASTRONOMY. By coincidence, during her visit to Antarctica, Beth toured the South Pole astronomical projects and suggested we do a story about them. We were delighted.

Meanwhile, she sold her original story on the Antarctic convergence to our sister publication, *Earth* magazine. You will find it there in the coming months.

Bonnie Bilyeu Gordon

Bonnie Bilyeu Gordon

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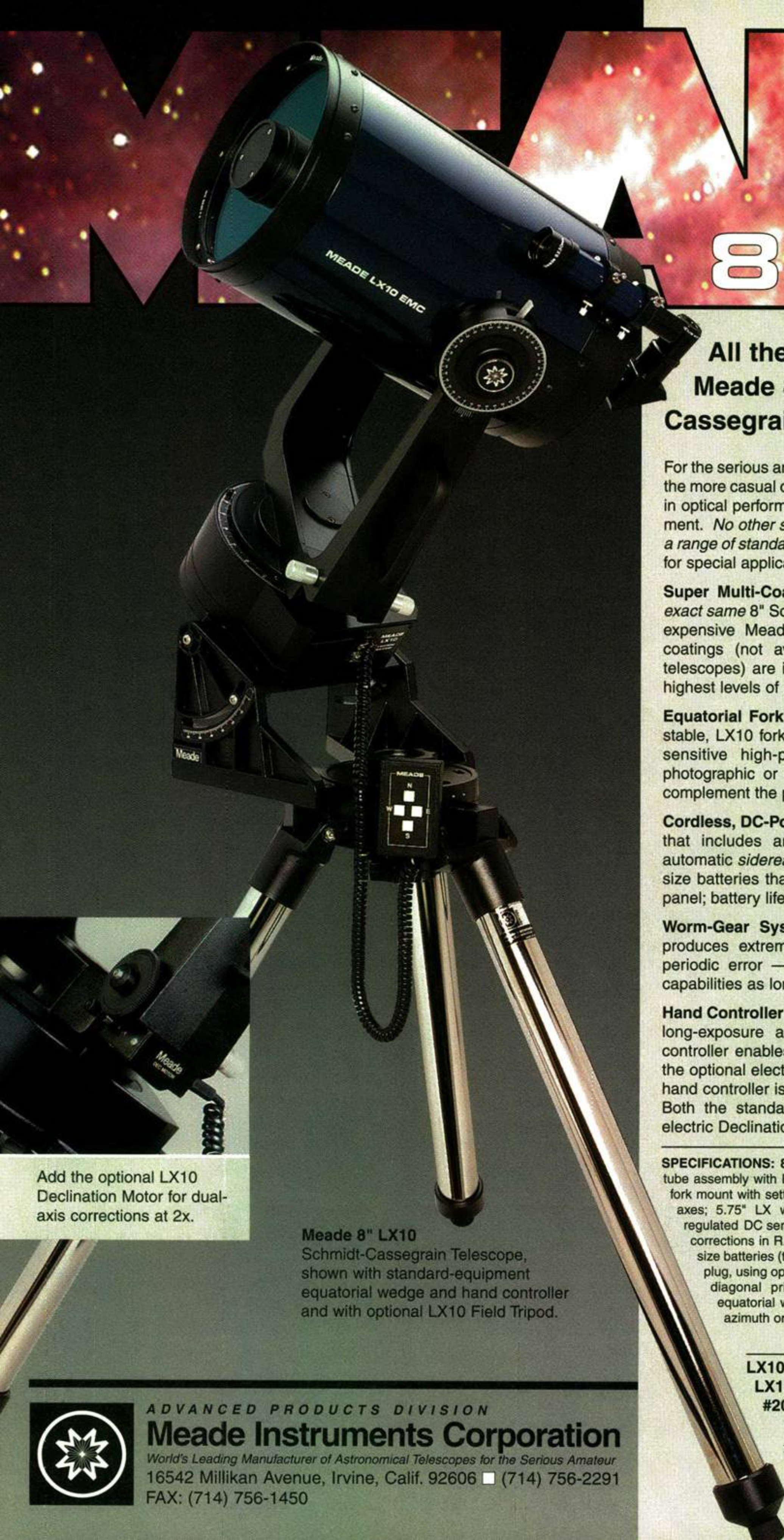
MEADE 8" LX10



Add the optional LX10 Declination Motor for dual-axis corrections at 2x.

Meade 8" LX10
Schmidt-Cassegrain Telescope, shown with standard-equipment equatorial wedge and hand controller and with optional LX10 Field Tripod.

All the optical performance of Meade 8" LX50 and LX200 Schmidt Cassegrains...for only *$995!*

For the serious amateur astronomer on a more limited budget, or for the more casual observer who nonetheless demands the very finest in optical performance, the Meade 8" LX10 satisfies every requirement. *No other similarly-priced 8" Schmidt-Cassegrain offers such a range of standard features* — or such a range of important options for special applications. *Standard-equipment includes:*

Super Multi-Coated Optical System: The LX10 includes the *exact same* 8" Schmidt-Cassegrain optical tube assembly as more expensive Meade 8" LX50 and LX200 models. Super multi-coatings (not available even as an *option* on competing 8" telescopes) are included with every LX10 optical system, for the highest levels of light transmission and image contrast.

Equatorial Fork Mounting: The relatively light weight, but very stable, LX10 fork mounting provides all of the rigidity required for sensitive high-power applications of the telescope, or for photographic or CCD imaging. Ball bearings on the polar axis complement the precise action of the internal worm gear system.

Cordless, DC-Powered Electronic Motor Drive: A drive system that includes an electronically-regulated DC servo motor for automatic *sidereal-rate* tracking. The drive is powered by four AA-size batteries that fit conveniently through the telescope's control panel; battery life is in excess of 50 hours.

Worm-Gear System: The LX10's 5.75"-diameter worm gear produces extremely smooth, regular motion in R.A., with low periodic error — a periodic error that permits such advanced capabilities as long-exposure astrophotography or CCD imaging.

Hand Controller: Essential for micro-guiding the telescope during long-exposure astrophotography, the LX10's pushbutton hand controller enables precise corrections in R.A. at 2x speed. With the optional electric Declination motor added to the telescope, the hand controller is functional at 2x speeds on both telescope axes. Both the standard-equipment hand controller and the optional electric Declination motor plug into the telescope's control panel.

SPECIFICATIONS: 8" Model LX10 — Includes 8" Schmidt-Cassegrain optical tube assembly with EMC super multi-coatings (D = 203mm; F = 2000mm, f/10); fork mount with setting circles, manual slow-motion controls, and locks on both axes; 5.75" LX worm gear reduction system; sidereal-rate electronically-regulated DC servo motor drive; 4-pushbutton hand controller for 2x speed corrections in R.A.; battery compartment accepting four (user-supplied) AA-size batteries (telescope may also be powered from an auto cigarette lighter plug, using optional 25 ft. cord); 6 x 30mm viewfinder; eyepiece-holder and diagonal prism (1.25"); MA25mm multi-coated eyepiece; standard equatorial wedge with elevation scale, fine elevation control, and 360° azimuth orientation capability; complete operating instructions.
$995. (+ $65 packing & shipping in the 48 states)

LX10 Field Tripod	**195.**
LX10 Electric Declination Motor System	**85.**
#2014 Magellan I Telescope Computer System for LX10, with 12,218-object database	**375.**

The 94-page Meade 1996 General Catalog is available free of charge from Meade Instruments or from authorized Meade dealers. Prices shown are suggested U.S. mail-order prices.

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Meade Pictor 208XT
AUTOGUIDER/IMAGER
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complete ***$695***

Meade Pictor 416XT
AUTOGUIDER/IMAGER
complete ***$1695***
includes $800 Meade CCD Equipment System

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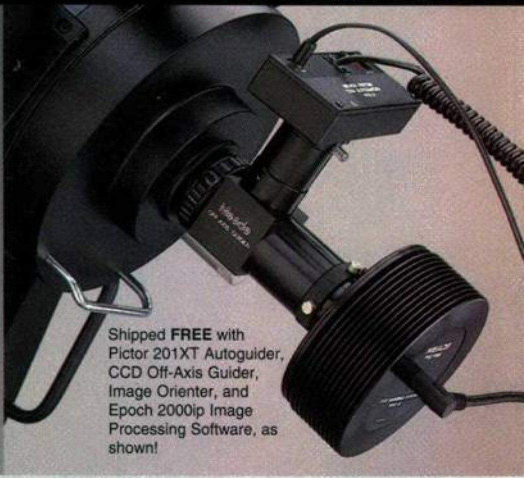
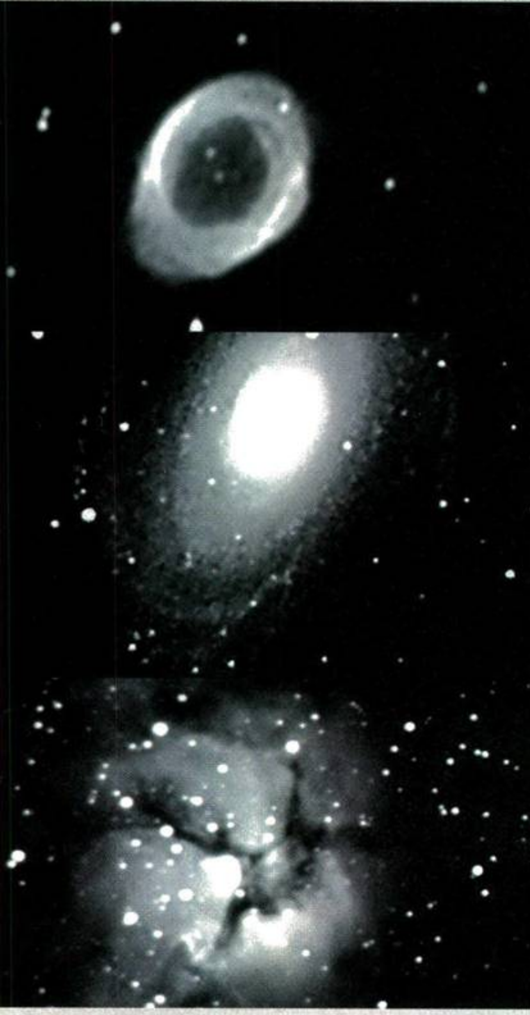
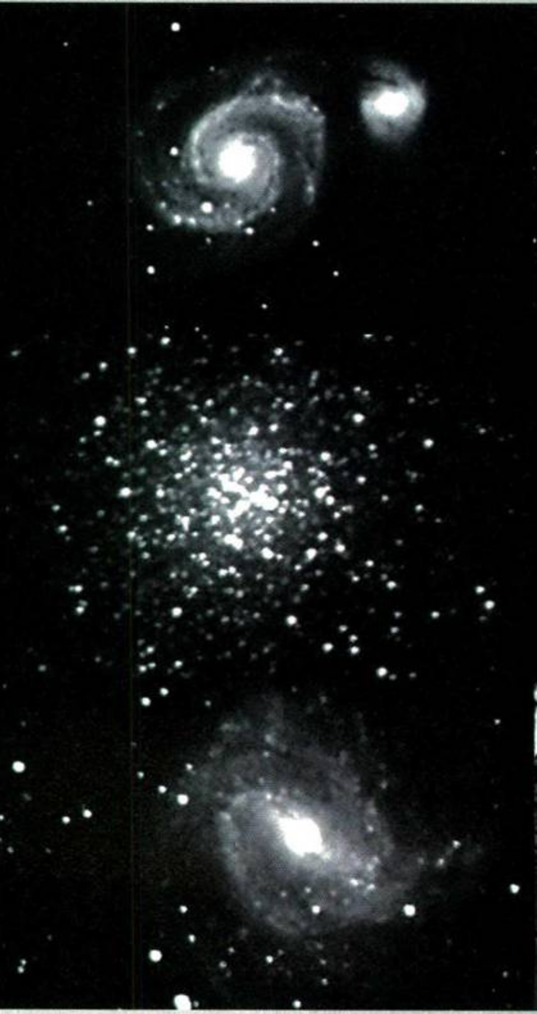
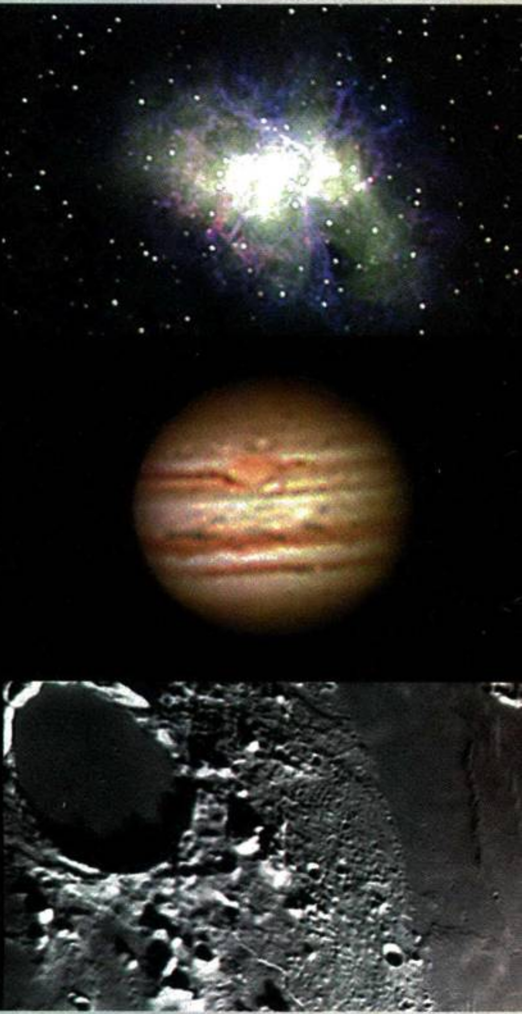

Shipped **FREE** with Pictor 201XT Autoguider, CCD Off-Axis Guider, Image Orienter, and Epoch 2000ip Image Processing Software, as shown!

Revolutionary Meade Pictor CCD's are now the world's largest-selling autoguiders and imagers for the amateur astronomer. No other electronic imaging systems offer such an incredible range of capabilities at such amazing price levels. At only **$495** the **Pictor 208XT** produces on the PC display fine, high-resolution 8-bit images *in seconds* of the Moon and planets, or, in 2 or 3 minutes, of thousands of deep-space objects. At **$695** the **Pictor 216XT** enables advanced 16-bit imaging and is *by far* the finest autoguider/imager ever made available at under-$1000. At **$1695** the **Pictor 416XT** permits professional-level imaging capability for the amateur astronomer: an electronic camera capable of producing with amateur telescopes images of the Moon, planets, and deep-space that match or exceed the photographic images obtained with many observatory telescopes. All models are available for immediate shipment. ***For complete information on Meade CCD imaging systems write, call, or fax for your free copy of the 94-page Meade 1997 General Catalog.***


Pictor 208XT images *(top to bottom):* Ring Nebula (M57), 25" reflector, Jack Newton; Galaxy (M81) in Ursa Major, 12" LX200, Scott Roberts; Trifid Nebula (M20), 8" LX200, John Hoot.


Pictor 216XT images: Whirlpool Galaxy (M51), 12" LX200, John Hoot; Globular Cluster (M13), 25" reflector, Jack Newton; Galaxy (M83) in Hydra, 12" LX200, Scott Roberts.


Pictor 416XT images: Crab Nebula (M1), 25" reflector, Jack Newton; Jupiter, 10" LX200 with Stellar Products AO-2 seeing adapter, Dr. Donald Bruns; Moon (crater Plato), 16" f/6 reflector, Dr. Donald Parker.

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MEADE SUPER PLÖSSL
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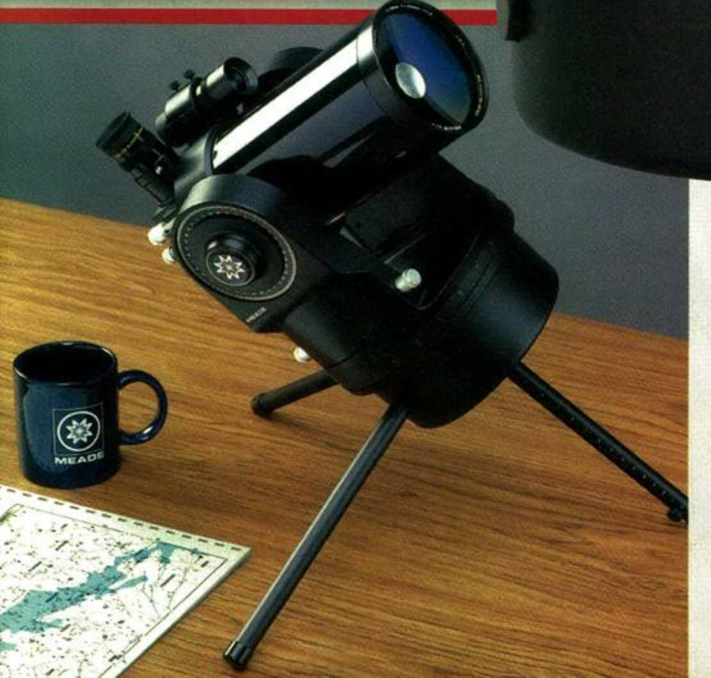
MEADE ETX

90mm Maksutov-Cassegrain

Meade ETX Astro Telescope. Shown with optional #64 Photo Adapter.

SPECIFICATIONS: ETX Astro Telescope— Includes Maksutov-Cassegrain optical tube assembly (D = 90mm, F = 1250mm, f/13.8) with EMC super multi-coatings; internal flip-mirror system for either straight-through or 90° observing position; equatorial fork mount with slow-motion controls, locks, and setting circles in R.A. and Dec; table tripod with elevation scale on center tripod leg; motor drive system with internal battery compartment accepting three (user-supplied) AA-size batteries; 8 x 21mm achromatic erect-image viewfinder; Series 4000 Super Plössl 26mm eyepiece (1.25"); operating instructions. *Net weight 9 lbs.* **$595***
(+ $20 packing and shipping in the 48 states)
*Suggested U.S. mail-order retail price.

Now you can have diffraction-limited imaging and ultraportability ...at only *$595*, *complete!*



The revolutionary Meade ETX goes anywhere with you at a moment's notice and presents the finest optical images ever made available in an ultraportable telescope.

Optical System: Manufactured at the Meade Irvine, California facility, ETX diffraction-limited optics produce images so high in contrast, brightness, and resolution that the ETX consistently outperforms telescopes of much larger apertures. **Equatorial Fork Mount:** Precise polar alignment in *seconds,* just by extending the center tripod leg to read your latitude on the inscribed scale. **Cordless Motor Drive:** The internal drive system operates from 3 AA-size batteries that power the motor drive for more than 50 hours. A North-South switch permits operation anywhere in the world. **Flip-Mirror System:** Flip the internal optical flat mirror "up" for 90° observing; flip the mirror "down" for terrestrial observing with the optional #932 45° Erecting Prism or for photography with the optional #64 Photo Adapter. **Standard accessories** include a Series 4000 Super Plössl 26mm eyepiece and 8 x 21mm erect-image viewfinder.

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MEADE STARFINDER DOBSONIANS

No other competing Dobsonians include this listing of *standard-equipment* features:

Primary and Secondary Mirrors of Low-Expansion Pyrex® Glass: Unlike the plate glass optics of other Dobsonians that can become thermally unstable, all Meade Dobsonian optics are made of Grade-A fine-annealed Pyrex glass — the exact same professional-quality optics used on Meade Starfinder Equatorials.

Rigid, Durable, Beautiful Dobsonian Mountings, manufactured of cabinet-quality materials, provide extremely smooth motions of the telescope in both altitude and azimuth. Both telescope axes ride on zero-backlash Teflon/Nylon bearings, facilitating the quick location and easy tracking of celestial objects.

Full-Size 1.25" Rack-and-Pinion Focuser: For smooth, precise focusing of the image without wobble or backlash. Focus travel is 2.6"; accepts 1.25" eyepieces.

4-Vane Steel Secondary Mirror System: Permits locked-in support and precise centration and alignment of the secondary mirror.

Multi-Coated MA25mm Eyepiece (1.25"): The Meade Modified Achromatic 25mm eyepiece yields sharp, high-resolution imaging to the field edge.

5 x 24mm Viewfinder: Included with all Starfinder Dobsonian models for quick object-location in the main telescope. With crosshair eyepiece and 2-ring bracket.

Optical Tubes: Starfinder Dobsonians include the same strong, spiral-wound Sonotube™ optical tubes used on Starfinder Equatorials *(right),* tubes with excellent insulating characteristics that reduce internal thermal currents to an absolute minimum.

Performance! *Meade Starfinder Dobsonians and Equatorials are the largest-selling Newtonian reflectors of their apertures in the world.* Every Starfinder model opens up the skies to an extremely wide range of serious visual observing; all 110 Messier objects, thousands of NGC objects — nebulae, galaxies, star clusters, in all their variations of form, color, and extent, as well as the Moon and planets in stunning high-resolution detail. Starfinder Dobsonians are telescopes for visual observing; motor-driven Starfinder Equatorials may be used, in addition, for lunar and planetary photography, and even for limited deep-space photography.

Packing & UPS Shipping Charges to any address in the 48 states: 6"—$39; 8"—$49; 10"—$69; 12.5"—$79; 16"—$45 packing, shipped truck freight collect.

Dobsonian Deluxe Accessory Package only $49.95!

Outfit your Meade Dobsonian with all of the most popular accessories for advanced observing. At the time you order any Dobsonian model, specify the following Deluxe Accessory Package for your telescope, in place of the standard-equipment focuser, viewfinder, and eyepiece, ***for a total of only $49.95 additional:***

- 1 - **Meade #77 2" Giant Rack-and-Pinion Focuser,** with machined aluminum eyepiece-holders for both 2" and 1.25" eyepieces; includes drawtube lock and 2.6" focuser travel. *(reg. $59.95)*
- 1 - **Meade #637 6 x 30mm Achromatic Viewfinder,** with wide 7° field; 2-ring metal bracket. *(reg. $49.95)*
- 3 - **Meade MA9mm, 12mm, and 25mm** multi-coated eyepieces, 1.25" barrel — eyepieces for the full range of lunar, planetary, and deep-space observing. *(reg. $37.95 each)*

Purchased separately, the Deluxe Accessory Package sells for $223.75!

Meade Magellan I Telescope Computer System

Attach the optional Magellan I Telescope Computer System to your Starfinder Dobsonian and finding any of 12,218 celestial objects, or *any* object of known R.A. and Dec., is almost as easy as pointing the telescope! Magellan I's database includes the following objects:

7,840	NGC objects; the complete NGC catalog
4,093	IC objects from the Index Catalog
125	user-defined objects
110	Messier objects; the complete catalog
42	alignment stars for the Magellan system
8	major planets, from Mercury to Pluto
12,218	objects, total

Magellan I is supplied *complete* with control/display unit (4" x 5" x 1.25"); premium-grade, high-resolution encoders for each telescope axis (encoder precision is 5.3 arc minutes); RS-232 serial interface; bracket for placement of the controller on the telescope tube; and attachment hardware. Just add the user-supplied 9v. transistor radio battery, and Magellan I is ready to use. First-time installation is quick and simple.

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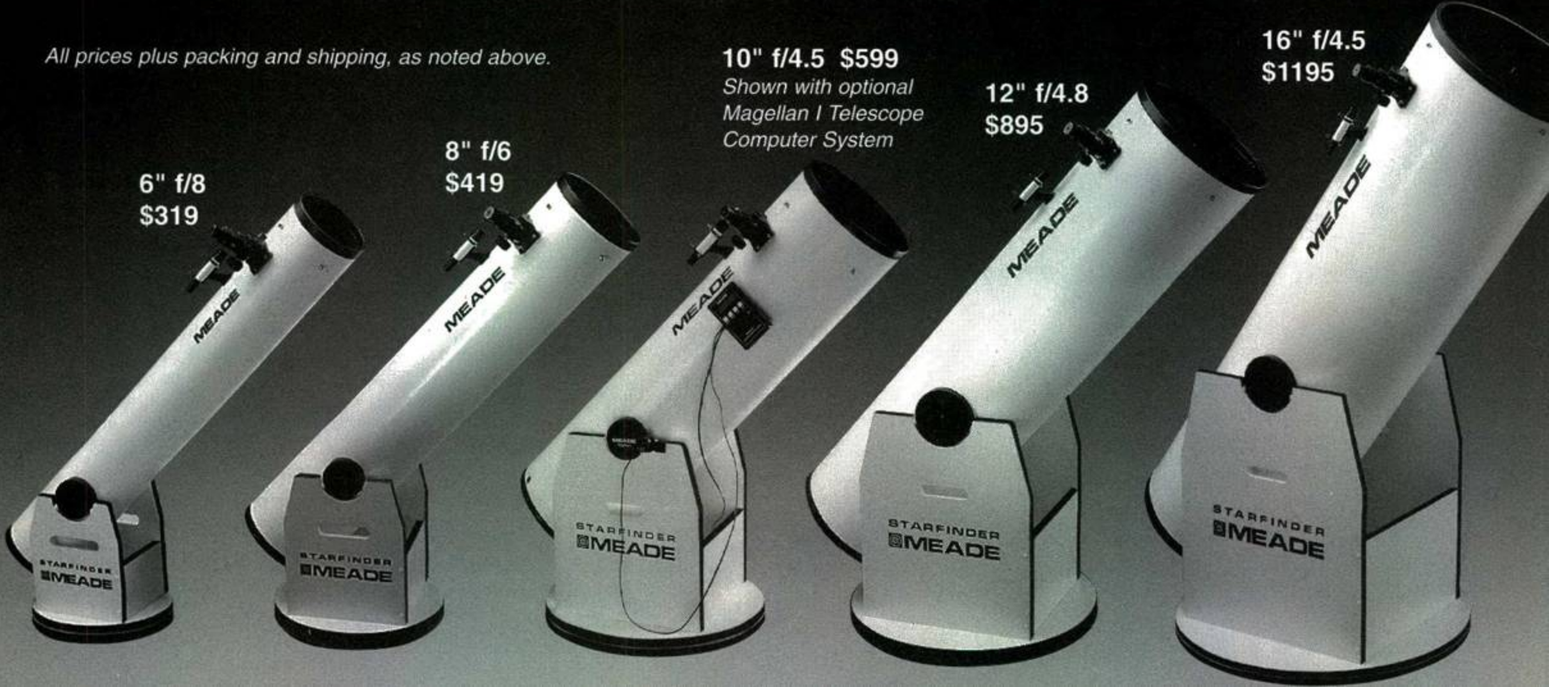
MAGELLAN I
TELESCOPE COMPUTER SYSTEM

#2010: for Meade Starfinder Dobsonian
6", 8", 10", 12.5", or 16" . . . . $295.
Packing & shipping in the 48 states—$15.

STARFINDER DOBSONIAN TELESCOPES ***Shown with standard-equipment 5 x 24mm viewfinder and 1.25" rack-and-pinion focuser.***

All prices plus packing and shipping, as noted above.



6" f/8
$319

8" f/6
$419

10" f/4.5 $599
Shown with optional Magellan I Telescope Computer System

12" f/4.8
$895

16" f/4.5
$1195

MEADE STARFINDER EQUATORIALS

Special Eyepiece Offer! At the time you order any Meade Starfinder Equatorial telescope, you can buy 2 additional multi-coated eyepieces, MA9mm and 12mm, ***for a total of $29.95!*** *Purchased separately, the 2 eyepieces sell for $75.90.*

The fullest exposition of Meade astronomical telescopes, CCD imagers, and telescope accessories is contained in the 94-page Meade 1997 General Catalog.

Write, call, or fax Meade Instruments for your free copy!

DC-powered drive systems for fully automatic tracking, and a wide range of standard-equipment features:

Professional-Grade Optical System: Includes hand-figured, parabolic primary mirror and elliptical flat secondary, both of Grade-A Pyrex glass. Optics are multi-coated and meet the theoretical limits of resolution.

Precision Equatorial Mount: Manufactured of machined aluminum to tolerances of .001" or better, with 4"-dia. pier and die-cast tripod legs for rock-solid support of the optical tube. Moves effortlessly from object to object on precision bearing surfaces. Polar and Dec. shafts are 1" solid steel. Setting circles on both axes.

Battery-Powered Cordless Drive System! Provides fully automatic tracking of celestial objects. Operates for more than 50 hours from 6 (user-supplied) AA-size batteries. Control panel also permits powering the telescope from 12v. auto cigarette lighter plug, using optional 25 ft. cord.

2" Giant Focuser: Meade #77 2" giant rack-and-pinion focuser is included as standard equipment, with eyepiece-holders for both 2" and 1.25" eyepieces.

Accessories and Components: #637 6 x 30mm viewfinder with wide 7° field; multi-coated MA25mm eyepiece (1.25"); strong, durable, spiral-wound optical tube with attractive white finish.

Starfinder Equatorial 16: Includes equatorial mounting with 1.5" steel shafts, Sealmaster ball bearings, 6" dia. pier, and 6 x AA-size battery-powered worm gear drive; 8 x 50mm viewfinder; #77 2" giant focuser.

Packing & UPS Shipping Charges to any address in the 48 states: 6"—$65; 8"—$75; 10"—$90; 16"—$55 packing, shipped truck freight collect.

Meade Magellan Telescope Computer Systems

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TELESCOPE COMPUTER SYSTEM

Magellan I: Use the Magellan I computer to manually slew the telescope quickly to any of 12,218 database objects, or to any object of known R.A. and Dec. Specifications and object database are identical to Magellan I for Starfinder Dobsonians *(see facing page).*

#2011: for Meade (DC-powered) Starfinder Equatorial 6", 8", or 10" .... $295.
#2012: for Meade (DC-powered) Starfinder Equatorial 16" .... 295.

MEADE
MAGELLAN II
COMPUTER-CORRECTOR
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Magellan II Computer-Corrector: Plug the Magellan II into the control panel of your Meade Starfinder Equatorial and you have all the capabilities of the Magellan I, above, including 12,218-object database, *plus* a 4-speed (2x, 8x, 16x, 32x), dual-axis, drive corrector/microslewing system.

#2018: for (DC-powered) Starfinder Equatorial 6", 8", 10" .. 495.
#2019: for (DC-powered) Starfinder Equatorial 16" .... 595.

Packing & shipping in the 48 states: Magellan I–$15, Magellan II–$20.

To Order: Contact your authorized Meade Advanced Products Dealer. Prices shown are suggested U.S.A. mail-order retail prices.

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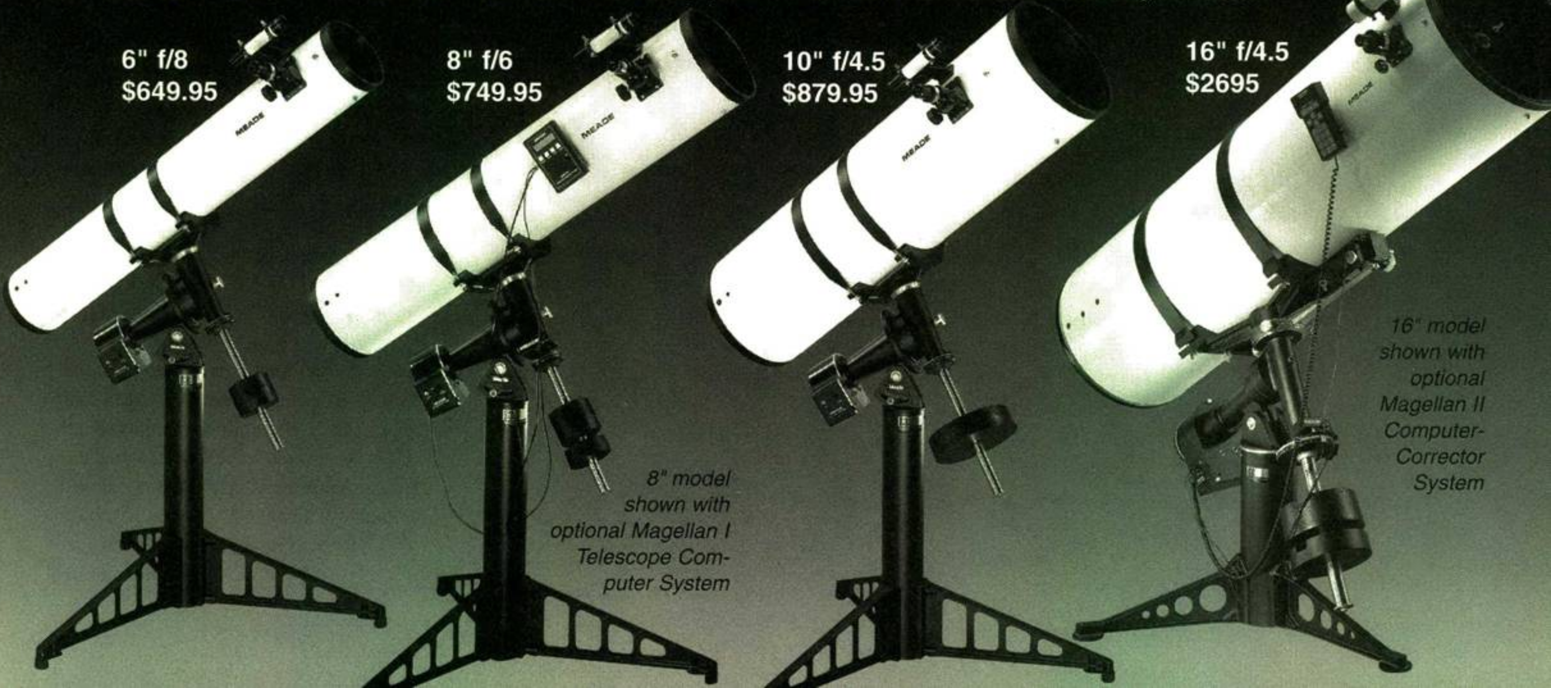
STARFINDER EQUATORIAL TELESCOPES ***Shown with standard-equipment 6 x 30mm or 8 x 50mm viewfinder and 2" giant focuser.***



8" model shown with optional Magellan I Telescope Computer System

16" model shown with optional Magellan II Computer-Corrector System

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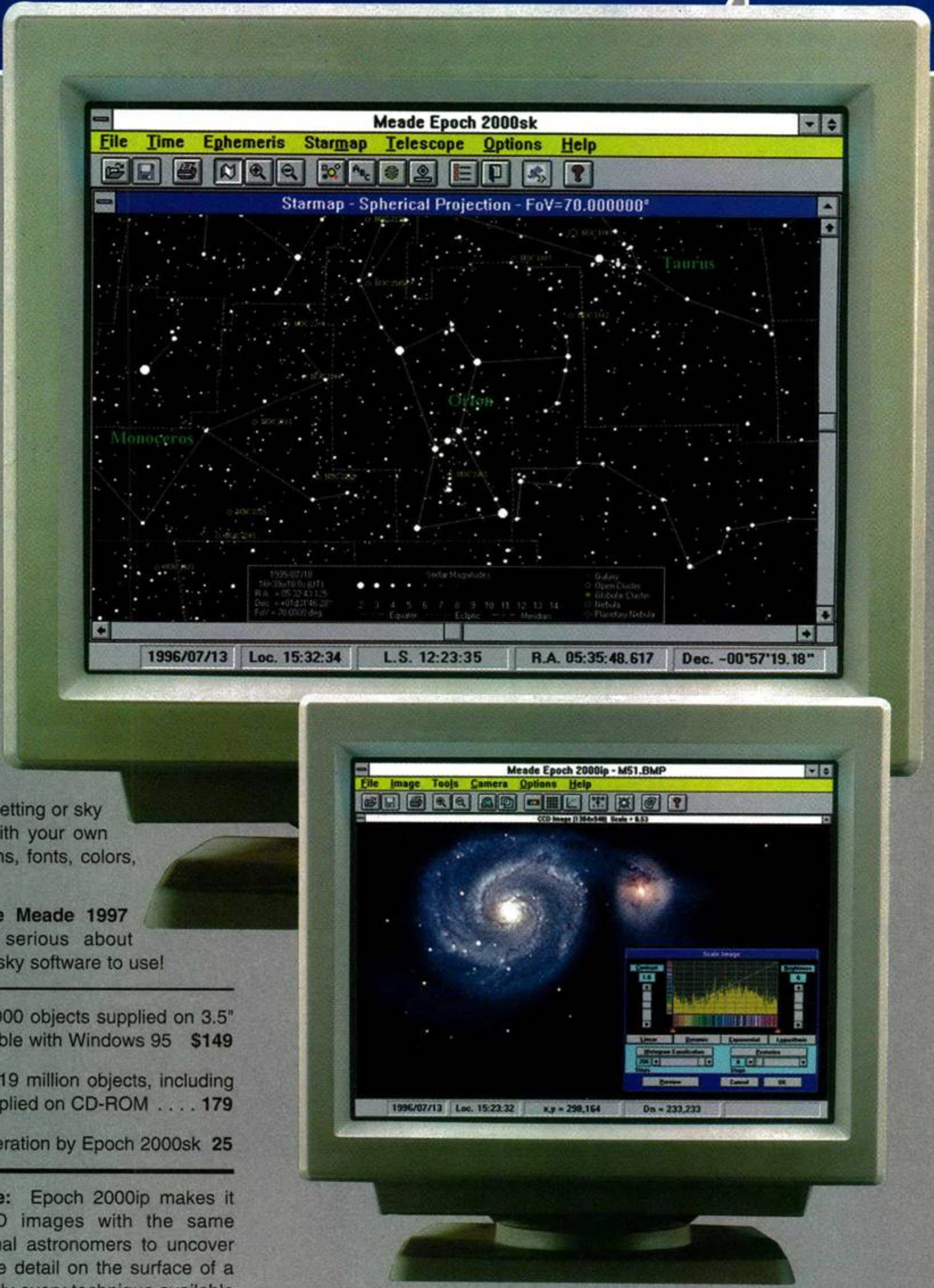
Meade Epoch 2000sk
File Time Ephemeris Starmap Telescope Options Help
Starmap - Spherical Projection - FoV=70.000000°
Taurus
Orion
Monoceros
1996/07/13
Loc. 15:32:34
L.S. 12:23:35
R.A. 05:35:48.617
Dec. -00°57'19.18"
Meade Epoch 2000ip - M51.BMP
File Image Tools Camera Options Help
Scale Image
1996/07/13
Loc. 15:23:32
x,y = 298,164
Dn = 233,233

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Now you can use the most advanced, most precise sky software ever created, to zoom-in on telescopic fields **smaller than one arc second!** With star positions displayed as precisely as **0.01 arc second,** no longer is the Trapezium in Orion, for example, shown as a single point as in other software, **but as four precisely oriented starpoints, just as they appear in the telescope.** No longer do you need to guess the R.A. and Dec. of an object located away from the field center, as in other programs: Epoch 2000sk dynamically reads out the R.A. and Dec. of the cursor position anywhere in the field **and updates R.A. and Dec. instantaneously as the cursor is moved about the field.** Meade LX200 owners can use Epoch 2000sk for remote auto-centering of objects in the telescopic field **to a precision of 30 arc seconds,** routinely!

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LX200 Interface Cable: for Meade LX200 operation by Epoch 2000sk **25**

Epoch 2000ip Image Processing Software: Epoch 2000ip makes it easy to enhance and analyze your CCD images with the same sophisticated techniques used by professional astronomers to uncover hidden structure in a spiral galaxy or obscure detail on the surface of a planet. This powerful software includes virtually every technique available for image enhancement. Techniques that bring out detail totally invisible in your original image, transforming it from the ordinary to the spectacular.

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EYEPIECES AND ACCESSORIES

Series 4000™ Super Plössls
52° field; multi-coated

Meade 4-element Super Plössls, updated and redesigned to utilize the latest in optical glass-types, are the finest general-purpose eyepieces available. For observing hairline lunar and planetary detail, splitting close doubles, or for deep-space; guaranteed to deliver more contrast and image sharpness than any other brand. Rubber eyeguards fold down for eyeglass wearers–a feature not available on competing brands. Multi-coated. All focal lengths through 32mm are parfocal.

Super Plössls (SP; 4-elements; 1.25"; 52°):

6.4, 9.7, 12.4, 15, 20, 26mm	each:	**$79.95** (3.45)
32mm (52°); **40mm** (44°)	each:	**99.95** (3.79)
56mm (52°; 2")		**199.95** (5.48)

Series 4000™ Ultra Wide Angle 84° field; multi-coated

The ultimate eyepieces; extreme image sharpness over an amazing 84° field. A perfect optical match with Schmidt-Cassegrains and fast Newtonians.

Ultra Wide Angle (UWA; 8-elements; 1.25"; 84°)– **4.7mm: $169.95** (3.94); **6.7mm: 199.95** (3.94); **8.8mm** (1.25"/2"): **239.95** (5.87); **14mm** (1.25"/2"): **299.95** (6.28)

Series 4000™ f/6.3 Focal Reducer/ Field Flattener

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5" at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture.

$129.95 (3.60)

2x Telenegative Barlow (1.25")

#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25"

$47.95 (3.45)

2x Short-Focus Barlow (1.25")

#126: Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of the #122, above. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated.

$47.95 (3.45)

2x-3x Variable Barlow (1.25")

#127: Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated; 1.25".

$59.95 (3.45)

2" Diagonal Mirror

#929: Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. Includes multi-coated precision optical flat made at the Meade factory; with 1.25" eyepiece adapter. **#930:** Same as #929 but with 2" barrel to fit into focusers with 2" eyepiece-holders.

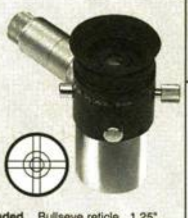
#929 or **#930**, each: **$99.95** (5.87)

45° Erecting Prisms

Fully coated roof prisms to invert the astronomical image in Schmidt-Cassegrains or refractors during terrestrial observations, while presenting a convenient 45° observing angle. Specify **#927** (.965"), **#928** (1.25"), or **#931** (fits .965" focuser, accepts 1.25" eyepieces).

$42.95 (3.45)

World's Most Advanced Illuminated Reticle Eyepiece



Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Multi-coated optics. **Internal batteries included.** Bullseye reticle. 1.25".

$149.95 (3.45)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator.

$129.95 (3.45)

Series 4000 Photo-Visual Color Filters (1.25")–Premium filters, made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

#8 Lt. Yellow; #11 Yellow Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue

each **$14.95** (2.29)

Set #1–4 filters: #12, #23A, #58, #80A	**49.95** (2.98)
Set #2–4 filters: #11, #25A, #47, #82A	**49.95** (2.98)
Set #3–4 filters: #8, #21, #38A, #56	**49.95** (2.98)

Series 4000 Moon Filter (#ND96): Reduces glare and irradiation during lunar observing. 13% uniform light transmission across the visual spectrum. Threads into 1.25" barrels. **$16.95** (2.29)

#905 Variable Polarizer (1.25")

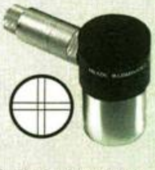
For glare reduction in observing the Moon. Includes two Polarizer filters mounted in a machined cell and permits continuously variable light transmission from 5% to 25%, to compensate for varying lunar surface brightness according to the Moon's phase and the aperture of the telescope. Accepts 1.25" eyepieces. **$49.95** (4.27)

Modified Achromatic Eyepieces

Meade 3-element MA eyepieces yield sharp, well-corrected images on the Moon, planets, and deep-space at a reasonable price. Multi-coated; threaded for filters; 1.25" barrel diameter. Apparent field: 40°. **MA 9, 12, 25, 40mm.**

each: **$37.95** (3.45)

MA12mm Illuminated Reticle Eyepiece



Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle. Wireless red LED illuminator and variable brightness control. 1.25" **Batteries included.** **$99.95** (3.45)

As above but with 6 ft. cord and plug for Meade telescopes with power panels, in place of wireless illuminator. **$79.95** (3.45)

Camera Adapters

Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-mount, available separately.

.965": **$27.95**; 1.25": **$29.95** (2.98)

Variable Tele-Extender

For eyepiece-projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Sliding cell with lock permits wide range of projection magnifications with the same eyepiece. Use with T-mount for your camera.

$39.95 (2.98)

Variable-Projection Camera Adapter (1.25")

Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-mount for your camera.

$39.95 (2.98)

T-Adapters for SCT's

Rigidly couples camera to telescope for prime focus photography with any Meade or Celestron Schmidt-Cassegrain. Use with T-Mount for your 35mm camera.

$26.95 (2.98)

Series 4000™ 2x Apochromatic Barlow Lens

#140: The most advanced Barlow lens available for commercial telescopes, the Meade #140 includes 3-element, multi-coated, air-spaced optics. Doubles the power of any eyepiece with which it is used and yields images absolutely unmatched in resolution, contrast and color correction. The #140 optically complements any telescope — refractor, reflector, or Schmidt-Cassegrain. Accepts 1.25" eyepieces. Mechanical components are of machined aluminum and brass. Lens diameter is 28mm; clear aperture 26mm.

$79.95 (4.27)

Series 4000™ Super Wide Angle 67° field; multi-coated

For exquisite wide-angle images at low-to-medium powers, with pinpoint edge-of-field resolution. Ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8mm, 18mm, and 24.5mm are superb complements to the #140 Barlow, above.

Super Wide Angle (SWA; 6-elements; 1.25"; 67°)–**13.8mm: $139.95** (3.94); **18mm: 149.95** (3.94); **24.5mm: 179.95** (4.68); **32mm** (2"): **239.95** (5.87); **40mm** (2"): **299.95** (6.28)

Series 3000™ Plössls 50° field; multi-coated

The very latest in eyepieces from Meade optical designers, new Meade Series 3000 Plössls yield the finest image corrections obtainable from the classical 4-element Plössl design. Available in a wide range of focal lengths from 5mm through 25mm. All five eyepieces are parfocal, so that, at most, only slight refocusing of the image is necessary from eyepiece to eyepiece. Unlike competing moderately-priced Plössls, Meade Series 3000's are **multi-coated** for maximum light transmission and image contrast. Chrome-plated brass barrels are threaded for standard filters. Manufactured exclusively for Meade Instruments by one of Japan's leading lensmakers, Series 3000 Plössls produce fine, high-resolution results on reflectors, refractors, and Schmidt-Cassegrains of any focal ratio.

Series 3000 Plössls (4-elements; 1.25"; 50°)
5, 6.7, 9.5, 16, 25mm each: **$49.95** (3.45)

#911B
#910B
#908B
#911N
#910N
#908N

Series 4000 Nebular Filters—Premium multi-layer interference filters, the finest obtainable. Use broadband ("B") filters to block most forms of light pollution; use narrowband ("N") filters in heavily light-polluted areas or for extremely high-contrast observing of faint nebulae.

#908B–Threads into 1.25" eyepieces, 26mm dia.	**79.95** (3.45)
#910B–Threads into 2" eyepieces, 44mm dia.	**119.95** (3.85)
#911B–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**99.95** (3.94)
#908N–Threads into 1.25" eyepieces, 26mm dia.	**89.95** (3.45)
#910N–Threads into 2" eyepieces, 44mm dia.	**129.95** (3.85)
#911N–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**119.95** (3.94)

Series 3000™ Plössl 40mm 44°

An excellent complement to the Series 3000 Plössls above, this all-new Plössl 40mm produces spectacular low-power, wide-field results with any telescope. Includes classical 4-element Plössl optics, **multi-coated.** Barrel dia. 1.25"; threaded for filters. Apparent field: 44°.

$79.95 (3.79)

HOW TO ORDER

■ Prices shown are suggested U.S.A. mail-order retail prices and do not include any applicable sales taxes.

■ Suggested shipping and handling charges to the 48 states by U.P.S. or U.S. Mail shown in ( ) next to each price.

■ Meade accessories may be ordered from any Meade Advanced Products Dealer. **The following national mail-order dealers carry all Meade accessories in-stock for immediate shipment:**

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ASTRO LETTERS

AS EACH STARSHIP CAPTAIN UNDERSTANDS SO WELL, THE UNKNOWN THAT MUST BE CONQUERED, AND THAT MEANS WE MUST BOLDLY GO WHERE NO ONE HAS GONE BEFORE...
STAR TREK THE EXHIBIT
e McLaughlin Planetarium

Robert Bateman

In December 1996, Robert Bateman returned to his childhood planetarium in Toronto, Canada. Instead of attending a show about stars and the universe, he found a science fiction exhibit.

Science Fact or Fiction? Does it Matter?

I was interested to read the article about the deterioration of North American planetaria ("Renaissance or Regret" by Claudio Veliz, January 1996), and how they are becoming places to show "laser rock-and-roll and science fiction exhibits." How true this is! I live in Tokyo, Japan, and in December 1996, I went home to Toronto, Canada, for Christmas. I remember going to McLaughlin Planetarium as a kid to watch shows about the planets, stars, and the universe. I was shocked to find the planetarium no longer showed thought-provoking shows about the heavens and was left with science fiction and fantasy shows. I am intrigued to learn that all may not be lost, and that the American Museum–Hayden Planetarium will be re-designed and opened in the year 2000. I too am waiting to see whether the new planetarium will be one of "flash and mere entertainment," or one bursting with vivacious, exciting scientific literacy. — *Robert Bateman, Tokyo, Japan*

I disagree with Veliz. The current trend is pulling us away from learning and education, specifically in the sciences. I think the planetaria management teams who have been "displacing a pursuit of excellence in scientific, educational content . . . in the name of securing profits through entertainment" are being scientifically and socially responsible.

If people are staying away from places of learning in droves, the way to attract them is to present something that they are interested in, such as the laser shows and science fiction exhibits. A person who attends such a show may stay for the science and fund the planetarium in the process. However, a person who has no motive for visiting a planetarium never will. — *Ian Randal Strock, Brooklyn, New York, irs@panix.com*

Claudio Veliz responds: Mr. Strock's perspective is unique and frightening: that planetaria maintain dignity and substance is not for science's sake, but for the public at large. If one takes Mr. Strock's suggestion, no barrier prevents conversion of planetaria to casinos or brothels. Surely a large sector of the public would attend. They might then stay for the science and fund the planetarium in the process.

If science is uninteresting to planetarium attendees, the fault lies in the lack of imagination and vigor by management. Lasers are surrender flags tantamount to failure. Indeed, if laser/rock shows succeed in inspiring individuals to attend programs on astronomy, why aren't they free? Apply some effort in showing the drama and wonder that science has a tradition of providing, then watch — a path will be beaten to your door.

Nothin' Like the Real Thing

I built a 6-inch Newtonian from a telescope making book and last night saw three incredible sights: the moon up close, Jupiter, and Saturn. I've seen pictures of these objects, but to see them for real through a telescope is an awesome sight. To see Jupiter hanging in the sky, Saturn and its rings, the craters of the moon, and to know they're hundreds of thousands or millions of miles away, is a humbling experience.

To anyone thinking of taking up astronomy as a hobby — do it. I can't wait to go out tonight. — *Gregory Clarke, Billerica, Massachusetts*

Trying to Fool Mother Nature?

The term balaclava (a knit cap for the head) used in "Suit up for Winter Observing" (January 1997), is unfamiliar to me, but an Arctic-grade hard-hat liner does a good job of keeping one's head warm. I've found the local welding supply to be a good place to look for "winter snuggies."

Military flight boots that folks wear ice fishing will keep your feet warm all night and they inflate to put air between the soles and your feet for insulation. — *Dave Wattles, Adrian, Michigan*

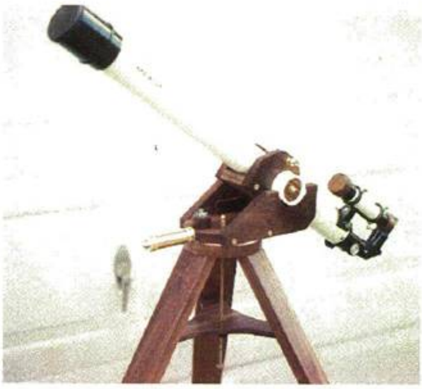
I'm concerned about John Shibley's advice in "Suit up for Winter Observing" (January 1997) when he suggests using cotton for the first layer to cover one's torso, fingers, and feet. Every outdoor enthusiast knows that cotton as a first layer in winter is bad news.

Cotton absorbs perspiration and the body loses warmth trying to heat the wet skin whether you are moving or standing still. The primary purpose of underwear is to transport moisture away from the skin and move it to the outer surface. Newer technology suggests using new polyesters that are non-absorbent by nature and make excellent layers next to the skin. — *Jean Tatasciore, Sherbrooke, Canada*

John Shibley responds: True, there are exceptional artificial fibers on the market today, such as "wicking" material, that draw moisture away from the skin. But I still feel nothing beats the combination of cotton for absorption and wool for insulation. The garment industry may try to imitate Mother Nature's fibers, but they have yet to surpass her efficiency.

Yes to Life on Mars

Confirmation of and consensus for the idea of life on Mars will eventually emerge either as a result of further analysis of meteoritic ejecta, or as a result of future surveying trips to Mars. I think that life is an emergent property of complex systems and it doesn't get much more complex than that swirling cosmic soup we look up into at night from our backyards.
— *Jeff Rawlings, Yellville, Arizona*


Alan Jones

Alan Jones built an heirloom mount for his department-store telescope.

A Mount to be Proud of

I just finished building a new tripod from your plans in "Redeem a Department-Store Telescope," (January 1997) and am pleased with the results. Minor changes were made to the plan because I wanted to make it an heirloom of walnut and brass. It turns smoothly in both altitude and azimuth and is a sturdy platform that doesn't wobble or vibrate.

Thanks to ASTRONOMY and David Trott. — *Alan Jones, Richardson, Texas*

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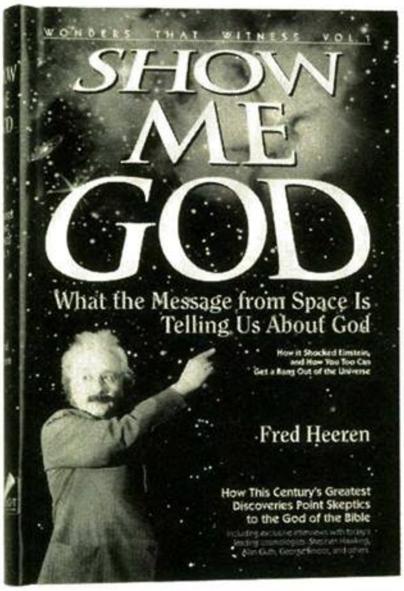
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ASTRO LETTERS

I started out with a tripod similar to the one that was rebuilt. I bought a 25-pound bag of lead shot for reloading. I emptied ⅓ of the lead shot and sewed the bag back up (you can even duct-tape it). I placed it on the triangular piece that holds the legs together and now it is very steady. This cost me $10 and 10 minutes of time. — *Lee Melody, Port Byron, Illinois*

The Early Bird Sees the Comet

On a –30° F morning on February 12, 1997, my wife and I were snowblowing our quarter-mile long driveway. At 5:30 a.m., I was star watching when I noticed a hazy "star" to the east. I grabbed my binoculars for a better view and lo and behold, it was comet Hale-Bopp. Neither my wife nor I had ever seen a comet so I brought out my 4-inch telescope. What a great view we had of the comet. It was a breathtaking experience, especially at –30°!
— *Randy Roseen, Warroad, Minnesota*

Astronomy Club Challenge

Every summer presents golden opportunities for astronomy clubs to bring more people into the hobby through county fairs, community celebrations, and other public events. With minimal effort, a club can access a dark area for public viewing. This benefits both the event and the club.

The work behind such an undertaking includes a call to those in charge of the event, a few press releases, perhaps a few handouts, and the set-up of telescopes.

For many of us, a simple view of the moon, Jupiter, or Saturn started our interest in the hobby. Who knows how many more individuals can be inspired with just a little effort on our part? — *Robert A. Krzewinski, Ypsilanti, Michigan*

Good-bye, Dr. Sagan

Carl Sagan was the best-known popularizer of science in the world. I learned of him in the early seventies when he studied exobiology. He was one of the first to seriously consider what kind of life could survive and thrive in a martian environment. He fully expected that life could have developed on that planet, which was a rather laughable idea in the early seventies.

I will remember him as a tough, fearless defender of the scientific method in a day of political correctness and a time of fundamentalist idiocy that strives to keep as many people as possible as ignorant of the workings of the universe as if we were still in the Middle Ages.

Sagan worked and lectured and debated tirelessly against creationists, parapsychologists, psychics, and other charlatans who would throw out all the laws of science and logic.

We owe a huge debt to Sagan, whose vision will be guiding scientists long after all of us are dead.
— *John R. Turner, Davenport, Iowa*

Most of us who read ASTRONOMY are aware of Sagan's accomplishments and realize what a great spokesman we have lost. With his charismatic personality, he explained space research in terms that all of us could understand and appreciate. His enthusiasm spilled out of the pages he wrote, filling our minds with the wonders the universe holds. The television programs and appearances he made left viewers spellbound at the immense size and complexity of the cosmos, of which we are only a small part.

My thoughts and prayers are with Sagan's family. He left an impression that will not be forgotten. — *Daniel Martinez, Corcoran, California*

ASTRONOMY's website (http://www.astronomy.com) brought me the tragic news of Carl Sagan's passing. I encountered him for the first time when "Cosmos" was aired in Australia. Exposure to this series contributed significantly to my love of astronomy. You said it all: "The universe now shines a little dimmer."
— *Keir Davies, Freemans Reach, Australia*

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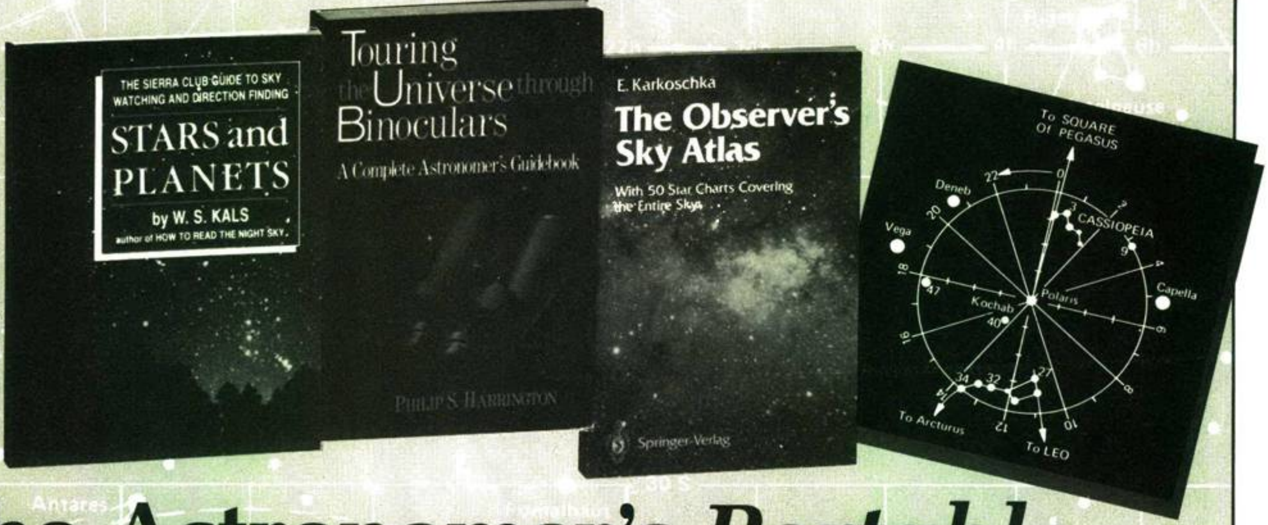
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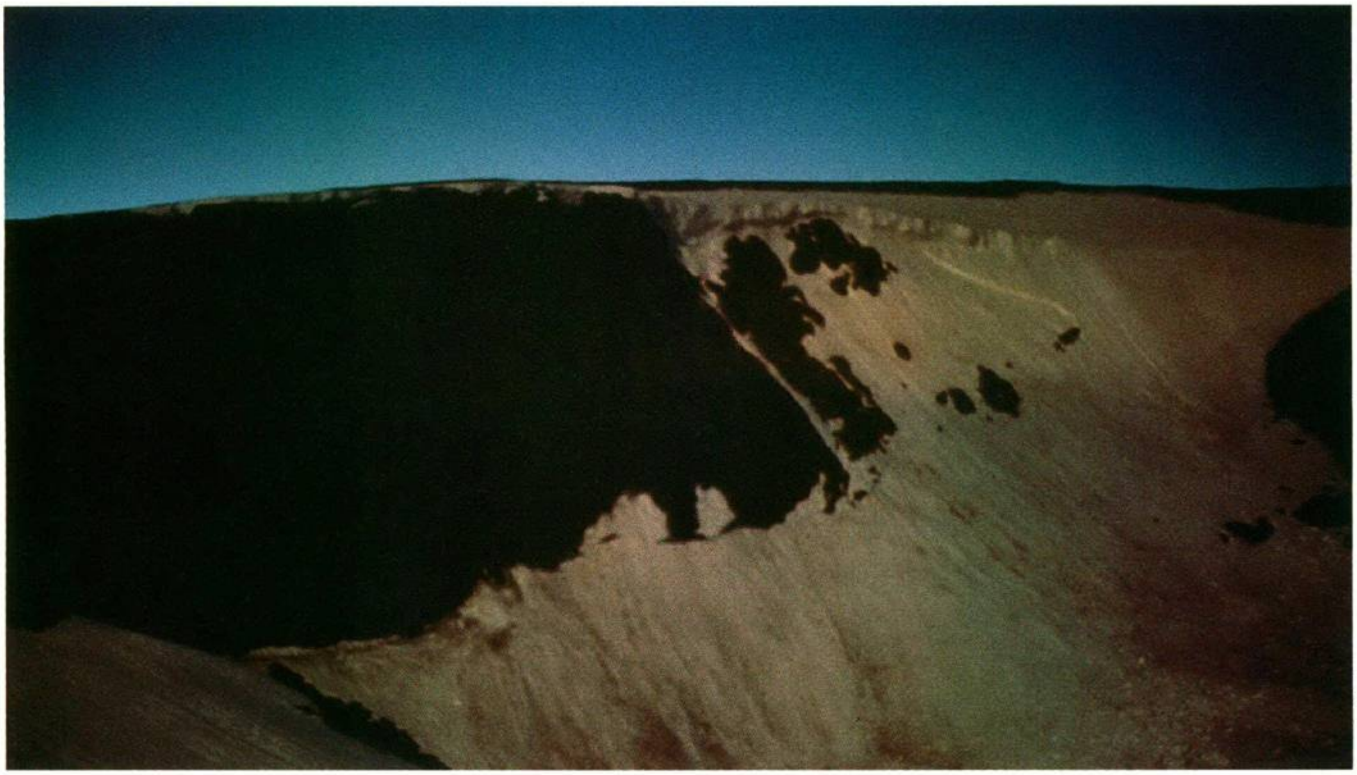
How Far Can You See?

by Brent Archinal



Brent Archinal

The snow-covered "Lava Cliffs" in Rocky Mountain National Park reflect the moon's light, as well as the lights of a passing car.

How far can the unaided human eye see? This is a question you often hear at star parties and astronomy meetings, or from a child who wonders "how far is far?"

And nearly as often, you'll hear the standard answer: The Andromeda Galaxy (M31) is the most distant object the human eye can see without optical aid. Most of what we see in the sky lies relatively close as "astronomical" distances go. The moon, sun, and planets are only light-seconds, minutes, or hours away. Most of the individual stars we see are light-years to centuries away. The unresolved stars that form the Milky Way lie farther away, as do the globular star clusters that populate our galaxy's halo. These latter objects push the limit of observable distances out to tens of thousands of light-years. Yet the Andromeda Galaxy, visible as a faint smudge on a clear night — often from even suburban skies — comes in at a whopping 2.4 million light-years away.

Some people have pointed out that another target lies a similar (or by some estimates, farther) distance away. The Pinwheel Galaxy (M33) in Triangulum can be glimpsed with the naked eye with only minor difficulty from a good dark site. Recent estimates place M33 at around 2.2 million light-years distant.

But are these the most remote galaxies visible to the human eye? In the April 1995 issue of the Webb Society's *Deep Sky Observer*, Lowell Observatory astronomer Brian Skiff suggested that the galaxy M81, which lies in northwestern Ursa Major and glows with a total magnitude of 6.9, should be visible without optical aid. A galaxy of that brightness might be near the limit of detection for a visual observer in a dark sky. However, M81 appears quite large on the sky and thus has a fairly low surface brightness. Skiff estimates that the inner 10' of the galaxy should glow at a magnitude of 7.5 and suggests it might be visible from a "dry, high-altitude, true-dark site."

As luck would have it, the day after reading that article, I left on a week-long trip to Boulder, Colorado, to attend a scientific meeting. I had one free weekend and planned to sightsee during the day and observe with the unaided eye and binoculars one evening. Saturday, July 8, 1995, found me making my way slowly across the nearby Rocky Mountain National Park. It was a splendidly clear day with reasonably warm temperatures — though there was still quite a bit of snow on the ground, especially at the higher elevations. The day brought some spectacular scenic views along the Trail Ridge Road, a trip across the continental divide at Milner Pass, and the pleasant experience of stopping by a quiet

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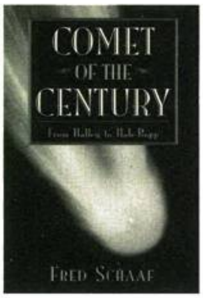

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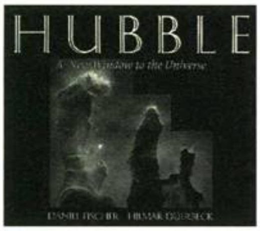

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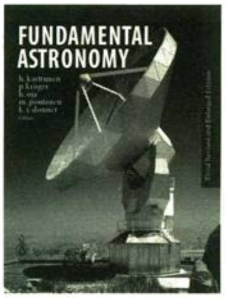

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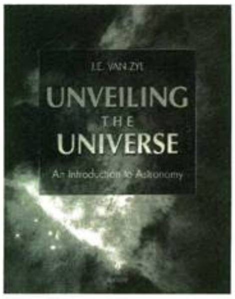

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stream in an idyllic meadow setting. It was only later that I realized this "quiet" stream went on to become the mighty Colorado River.

Heading back east in the evening, I stopped at the Gore Range Overlook to view a dramatic sunset. As the sky darkened, I struggled to decide whether to call it a day or stay and do some observing. The catch was that the moon was in a waxing gibbous phase that night, so it would be well into the early morning hours before I could observe under a moonless sky. I wasn't sure it was worth the effort to stay, even with the thought of taking up Skiff's challenge to observe M81. However, the beautifully clear skies and the sight of the moon, Jupiter, and Antares shining in the east helped me decide to stay.

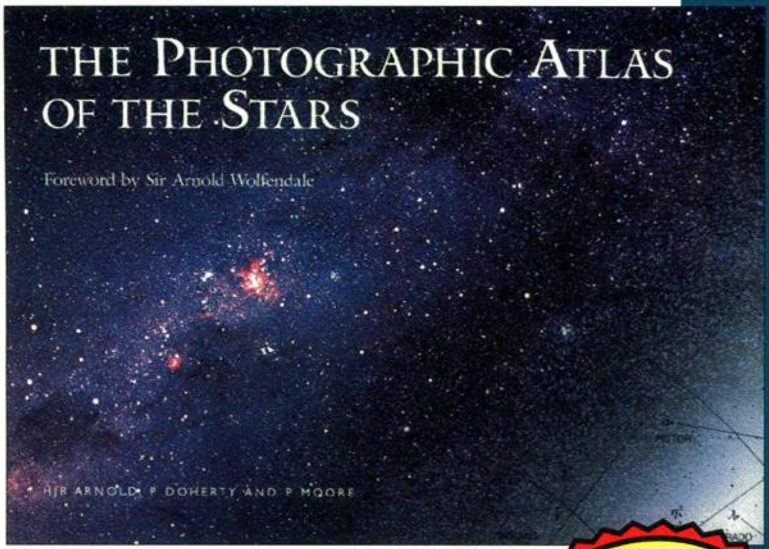
I stopped briefly to see the ice-covered, moonlit "Lava Cliffs" contrasted against the starry sky but settled at the nearby Rock Gap Overlook. Here, safe from the wind of the previous overlooks and still at an elevation of more than 12,000 feet, I spent much of the night. Even with a bright moon, much of the sky was darker and blacker than the skies ever reach in my more familiar settings in the eastern United States. After a few hours of observing, I slept intermittently in the car, awakened only by the few passing vehicles.

My watch alarm woke me at 3 a.m., and I bundled up to step outside into the near-freezing temperatures. I was greeted with the darkest sky I had ever seen in my life. The Milky Way was truly spectacular. The glow from Cygnus was nearly overwhelming, and the entire area around Cassiopeia and Perseus was sensational. In the southwest, Sagittarius gleamed with a strength I'd never seen before. The North America Nebula was an obvious naked-eye object overhead. In 7x35 binoculars, I easily saw the "West Virginia" cluster (NGC 6997) that lies within the nebulosity. While sweeping up and down the Milky Way, the binoculars had no difficulty showing me the Double Dark Nebula (B132 and B133) near Altair. They also revealed the Small Sagittarius star cloud (M24), one of the most spectacular objects in the southern sky, just south of the prominent dark nebulae B92 and B93. I observed one object after another, each looking different than ever before against such a black and transparent sky.

Around 3:30 a.m., I turned my attention to the northern part of the sky, below Polaris. The horizon, at least up to about 10° altitude, seemed to glow with some whiteness. At first I thought there might be a city in that direction but eventually realized the glow stretched completely around the horizon. Luckily it didn't interfere with my view, and I quickly located the area of M81. The binoculars showed it and its neighboring galaxy, M82, quite well. With my unaided eye (or at least wearing only glasses, which correct my slight nearsightedness), I quite easily saw with direct vision a star just to the left of M81. Later I determined that this was SAO 15100, at magnitude 7.2 certainly one of the faintest stars I'd ever seen this low in the sky.

At the same time I began to realize that there was a faint glow to the right of the star, visible only with averted vision. Could this be M81? The binoculars confirmed it — I was seeing the central part of the galaxy, although possibly with some stars involved. At this point I was fairly sure that I was seeing the galaxy itself, although I wasn't sure how much the stars were contributing to the total glow. It was only later that I verified the stars (SAO 15026 and SAO 15020) are much fainter than the galaxy, at magnitudes 8.8 and 8.7, respectively. I further checked what other faint stars could be seen in this area, and determined that no trace of the sliver of M82, M81's smaller and fainter companion, could be seen with the unaided eye.

So I had done it and, other than the very long trip to the observing site, it had been relatively easy. My naked-eye observation of M81 was not a marginal detection either — the galaxy was fairly easy to see with averted vision as a largish hazy spot to the right (west) of SAO 15100. And in retrospect, I was coping with sky conditions that probably weren't as



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perfect as I had first believed. For one thing, there seemed to be some haze present over much of the sky, perhaps fog from the nearby melting snow cover. For another, although I knew I was observing low in the northern sky, M81 was just about at lower culmination — the lowest it ever reaches from that site. In this case it was only about 20° above the horizon. Yet I had still seen M81 without any optical magnification — at 11.7 million light-years, now the most distant object that has been observed by the unaided human eye.

An obvious question arises: Can this observation be repeated by others? While writing this article, my friend Stephen J. O'Meara told me that he too has seen M81 with the unaided eye. He has also seen another, slightly closer, galaxy, M83 in Hydra. More recently, Aristides Tzarellas of Greece and Brian Skiff have both reported seeing M81 with the naked eye. These might be cases where, once an object has been pointed out as observable, it becomes fairly easy to observe. I'd certainly like to think so.

I imagine that galaxies like these will continue to be difficult, if not impossible, objects to observe from near the light-polluted skies of a city or through the ocean of air that exists over sites near sea level. However, I think that the limit has not been reached. From a truly dark-sky site, at high altitude with a dry atmosphere, an experienced young observer should easily be able to see M81, possibly even with direct vision. More important, it's quite possible that under such ideal conditions fainter and perhaps more distant galaxies can be seen with the unaided human eye. The question is whether anyone will take up the challenge. Will it be your eyes that make the observations? Will you be the next one to see farther with your eyes alone than any other human being ever before? □

Brent Archinal is an experienced deep-sky observer and an astronomer at the U. S. Naval Observatory in Washington, D.C.

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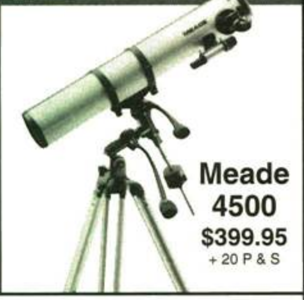

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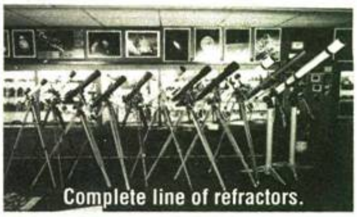

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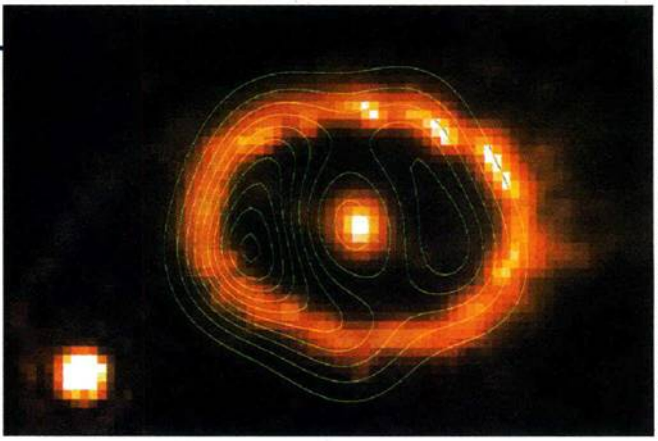
Supernova 1987A Begins to Brighten



Bryan Gaensler (Australia Telescope National Facility)

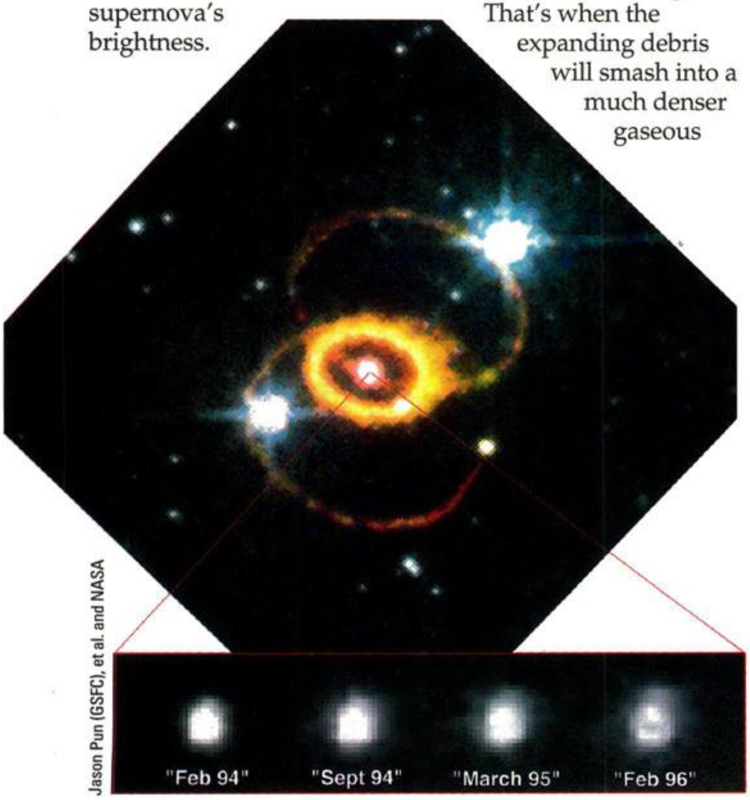
As the debris from Supernova 1987A hurtles outward at more than 5 million miles per hour, it is beginning to run into diffuse gas inside the large elliptical ring left by the progenitor star. An increase in radio emissions, shown as contour lines, is just a harbinger of the fireworks expected in another decade when the debris (the central bright spot) collides with the dense ring.

Ten years after first appearing in our sky, Supernova 1987A remains the focus of intense interest. As the nearest and brightest supernova seen since the invention of the telescope, SN 1987A in the Large Magellanic Cloud offers astronomers an unprecedented opportunity to observe the evolution of an exploding star. Recent observations confirm the beginnings of a predicted rebirth, which should produce a thousand-fold increase in the supernova's brightness.

No, the star isn't going to explode again. Instead, the outrushing debris from the supernova will collide with material gently blown off the progenitor star tens of thousands of years before the explosion. The first inkling of that collision has recently shown up in increased radio and X-ray emission.

The real show may be another ten years in the future, however, according to Kazimierz Borkowski of North Carolina State University and his colleagues. That's when the expanding debris will smash into a much denser gaseous ring, igniting a flare-up that should cause the supernova to brighten by a thousand times in visible light. (The debris is traveling outward at more than 5 million miles per hour compared with the ring's expansion velocity of 20,000 miles per hour.) Although the brightening won't return the supernova to its glory days of 1987 — at best it will glow around 13th magnitude — the display should prove spectacular when viewed through a large telescope.

The outrushing debris has finally grown large enough to show detail to the sharp eye of the Hubble Space Telescope. In observations taken over the past two years, Jason Pun of NASA's Goddard Space Flight Center and Robert Kirshner of the Harvard-Smithsonian Center for Astrophysics have resolved the debris into a surprising dumbbell-shaped structure about a tenth of a light-year long that consists of two expanding blobs. "This is the first time we can see the geometry of the explosion and relate it to the geometry of the large glowing ring system around the supernova," says Pun. "The images may yield important clues to the dynamics of the supernova explosion and the structure of the progenitor star."



Jason Pun (GSFC), et al. and NASA

Lying at the center of a three-ring circus created by its progenitor star, Supernova 1987A has finally started showing structure. These Hubble images show the evolution of the expanding debris over a two-year period. By February 1996, the debris had been resolved into two opposing blobs with a dark band across the center.

Galileo's Ice Floe Picture Show

NASA's Galileo spacecraft continues to peel back layers of mystery surrounding Jupiter's moon Europa. A flyby last December 19 brought the craft to within 430 miles of the satellite's surface to see hints of ice volcanos and ice floes, features consistent with the possibility that an ocean might lurk beneath an icy crust.

"This is the first time we've seen actual ice floes on any of the moons," says Galileo imaging team member Ronald Greeley. "These floes, as well as dark scarring on some of Europa's cracks and ridges, appear to be the remnants of ice volcanos or geysers."

Planetary scientists feel Europa's interior was hot enough at one time to create a subterranean layer of water or slush that fractured the moon's icy

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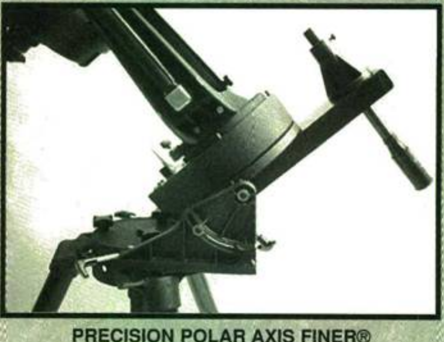

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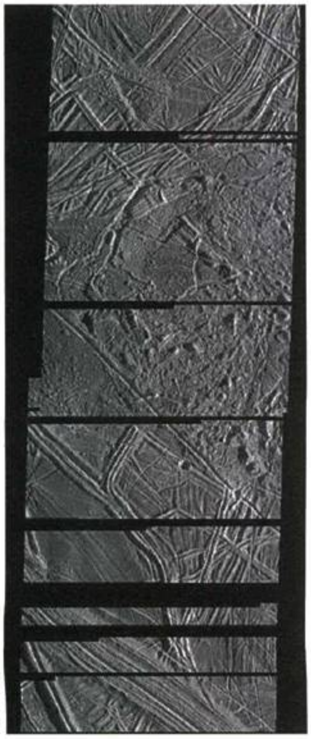
surface into floating plates. Some of the water shot up through cracks as geysers or volcanos. Whether Europa's interior is currently warm enough to sustain a buried ocean remains to be seen. The ramifications for possible life are obvious.

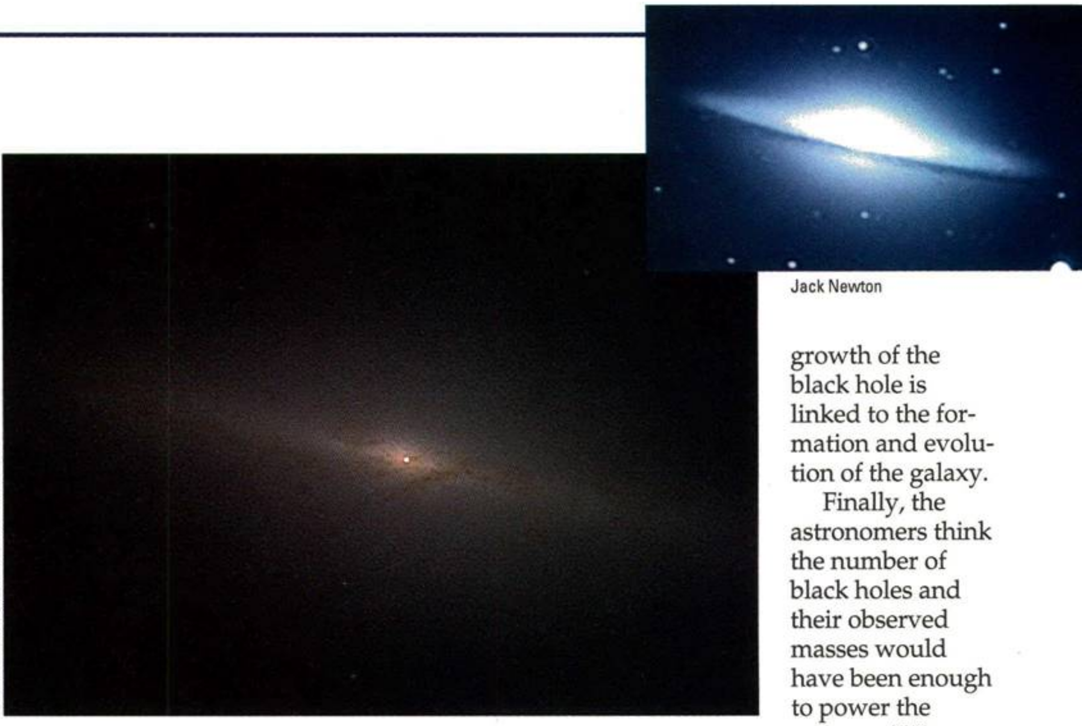
"There are three main criteria to consider for life outside of Earth: the presence of water, organic compounds, and adequate heat," says Greeley. "Europa has water ice, and organic compounds are prevalent in the solar system. The big question mark is how much heat is still generated in the interior."

Galileo scientists will have a better chance to figure out Europa's insides when Galileo makes another flyby in November 1997. They will plumb Europa's interior by looking at how the moon's gravity alters Galileo's trajectory during the flyby. That ought to provide clues about whether rock, ice, or even liquid water lies beneath Europa's tortured surface.



NASA/JPL

Recent images of Europa have not dispelled the notion that the jovian moon might harbor a subsurface ocean capable of supporting life. Ridges in this 11- by 30-mile mosaic are where water oozed up between cracks. Dark smudges in other images point to dormant ice volcanos or geysers. Galileo took these pictures when it flew 430 miles past Europa on December 19, 1996.



John Kormendy (Univ. of Hawaii), et al.

Jack Newton

The Sombrero Galaxy (M104) in Virgo (inset) harbors a one-billion-solar-mass black hole in its core. Astronomers weighed the black hole by measuring the velocities of stars in the vicinity of the galaxy's nucleus, the bright spot at the center of the Hubble image. The black hole itself lies in the nucleus, hidden by its bright surroundings.

Giant Black Holes Lurk in Galaxies

Astronomers conducting a census of nearby galaxies have concluded that nearly all large galaxies may harbor supermassive black holes in their cores. The black holes, which range in size from a few million to a few billion times the mass of the sun, probably powered luminous quasars in the distant past, though they have now grown quiescent.

Using the Hubble Space Telescope and the Canada-France-Hawaii Telescope on Mauna Kea in Hawaii, a team of astronomers led by Douglas Richstone of the University of Michigan has studied 15 galaxies in detail so far. Of those, 14 appear to contain supermassive black holes. The team takes high-resolution spectra of the galactic cores to measure the velocities of stars. A sharp rise in those velocities toward a galaxy's center betrays the presence of a black hole.

In addition to finding supermassive black holes in nearly every large galaxy studied, the astronomers also found that the mass of the black hole is proportional to the mass of its host galaxy. This implies that the growth of the black hole is linked to the formation and evolution of the galaxy.

Finally, the astronomers think the number of black holes and their observed masses would have been enough to power the quasars. "We believe we are looking at 'fossil quasars' and that most galaxies at one time burned brightly as quasars," says Richstone. These conclusions jibe with previous Hubble observations showing that quasars dwell in a variety of galaxies, from isolated normal galaxies to colliding pairs.

The efficiency of the black hole search should increase dramatically with the newly refurbished Hubble. The Space Telescope Imaging Spectrograph can simultaneously take spectra at several nearby positions in a single object, cutting the length of time needed to study each galaxy.

Remnants from Our Galaxy's Birth

Enigmatic clouds of hydrogen gas surrounding our galaxy are most likely debris left over from the formation of the Local Group of galaxies and may provide raw material for future generations of stars.

The clouds have puzzled astronomers ever since their discovery in

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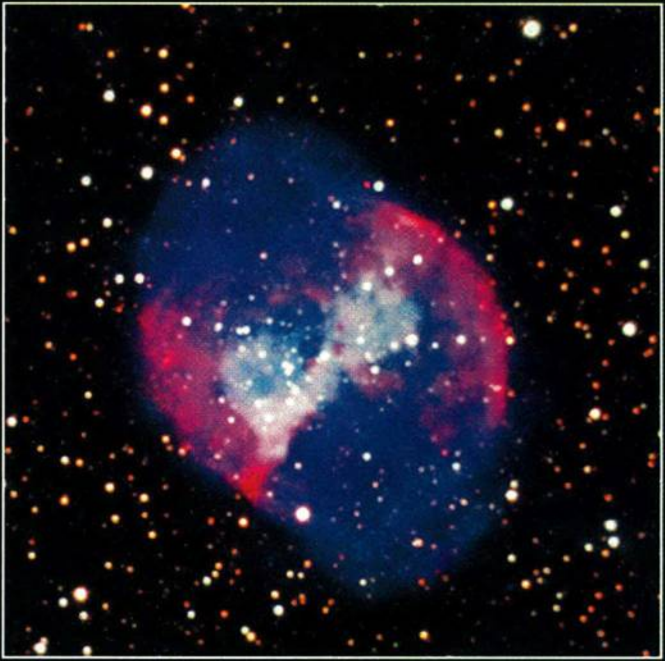
M27 Planetary Nebula. *1800 second exposure taken through a Red filter with the Model ST-7 CCD Imaging Camera and the CFW-8 Color Filter Wheel.*

M27 Planetary Nebula. *1800 second exposure taken through a Green filter with the Model ST-7 CCD Imaging Camera and the CFW-8 Color Filter Wheel*

M27 Planetary Nebula. *1800 second exposure taken through a Blue filter with the Model ST-7 CCD Imaging Camera and the CFW-8 Color Filter Wheel.*



M27 Planetary Nebula. As in all the planetary nebulae, the faint central star is an abnormally hot bluish dwarf with a spectrum resembling that of an ancient nova and a calculated surface temperature of about 85,000 degrees K., one of the hottest stars known. It is assumed that planetaries are formed by ejection of material from the hot central star, but the exact details of the process are unknown. Red, Green, and Blue Model ST-7 images were summed together and color balanced to create a true color image. *Courtesy of Benoit Schillings.*

Note: All images were processed from a computer disk to a standard photographic film using a Film Recorder. Courtesy of AstroPhoto, Oakview, California.

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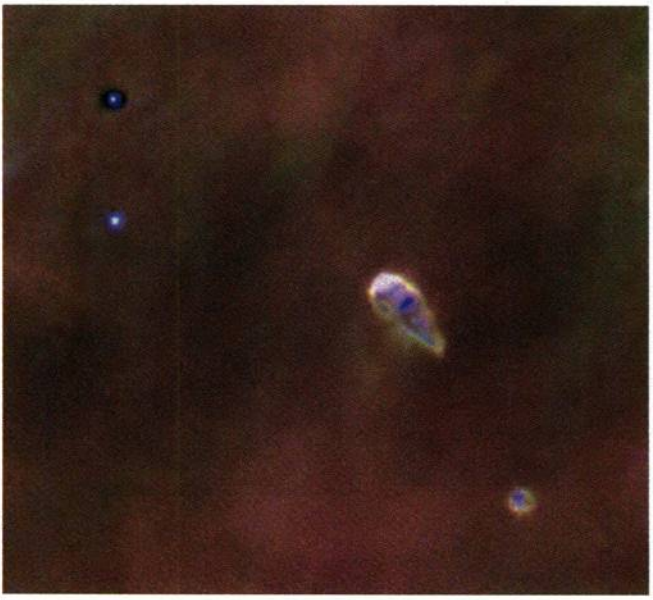
1963. Most of the hydrogen gas in our galaxy lies in the galactic disk, where it calmly orbits the center along with the galaxy's stars and dust. But the so-called "high-velocity clouds" move much too fast to be rotating with the rest of the galaxy. Some of these clouds seem to be falling into the galaxy, while others seem to be moving away.

Leo Blitz of the University of California at Berkeley and colleagues from the United States and the Netherlands have analyzed data from recent radio surveys and reevaluated previous observations from the Cosmic Background Explorer satellite and the Hubble Space Telescope. They found that the high-velocity clouds are bigger, farther away, and more massive than previously thought. In fact, the clouds seem to be orbiting the center of mass of the Local Group, a collection of more than 30 galaxies dominated by the Milky Way and Andromeda galaxies.

The researchers then ran a computer simulation that traced the history of the Local Group and found that they could reproduce the current positions and motions of the high-velocity clouds. This implies that the clouds we see now are remnants from the formation of the entire Local Group. Most of the clouds in the simulation were devoured by one of the two large galaxies, suggesting that the clouds serve as raw material for new stars. That's comforting because at the current rate of star formation, the Milky Way would run out of gas to make new stars in less than 100 million years, a mere blink of the eye on the cosmic timescale.



John Bally, Dave Devine, Ralph Sutherland, and NASA

Ultraviolet radiation from the Trapezium, four hot stars that illuminate the entire Orion Nebula, is eroding these disks that surround newborn stars. The disks are about the same size as the disk that formed the sun's retinue of planets.

Blowing Away Planets in Orion

It's an irony that the most beautiful astrophotos usually demonstrate nature's most violent and destructive processes. New Hubble Space Telescope images of the Orion Nebula show circumstellar disks of gas and dust being destroyed by nearby hot, massive stars. In a more serene environment, material in these disks would probably clump together to form planets. "It's kind of sad that what we're seeing here is quite likely the destruction of protoplanetary disks, disks that probably won't form planets," says Doug Johnstone of the Canadian Institute for Theoretical Astrophysics.

The disks are located within one light-year of four massive stars known as the Trapezium. The Trapezium stars, particularly Theta^1 C Orionis (the brightest of the four), give off intense ultraviolet radiation. The radiation zaps the outer part of the disks, heating the material and causing it to disperse. The process works quickly, eroding the disks within one million years.

Planet formation models predict that giant planets like Jupiter take up to 10 million years to form, meaning if planets are going to form near a massive star, they either have to form quickly or in the inner part of the protoplanetary disk. Johnstone sounds a note of optimism, however: "I wouldn't rule out life in the galaxy because there are many other regions where stars with disks are forming that don't have high-mass stars anywhere nearby."

John Bally, Dave Devine, Ralph Sutherland, and NASA

The four stars of the Trapezium are destroying protoplanetary disks around nearby stars. Ultraviolet radiation from the brightest of the four stars, Theta^1 C Orionis, pushes material away from it, forming the comet-like tails. This image covers 0.2 light-year from side to side.

Debate Over Mars Life Heats Up

The claim of life in an ancient martian meteorite continues to generate controversy. One group of scientists says their research rules out the possibility that minuscule martian critters once lived inside the meteorite ALH84001. The NASA team that reported evidence

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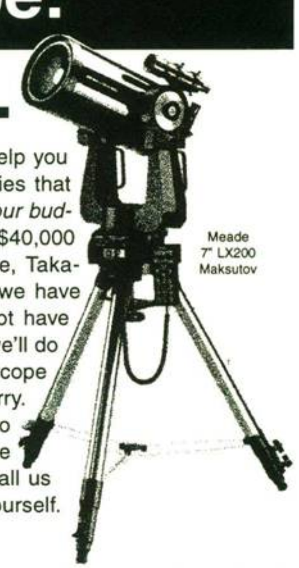
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for life in ALH84001 says nothing has changed.

Harry McSween of the University of Tennessee, Ralph Harvey of Case Western Reserve University, and John Bradley of the Georgia Institute of Technology, examined magnetite in ALH84001 with a sophisticated electron microscope. The NASA team had argued that martian organisms could have produced the magnetite, just as terrestrial bacteria produce magnetite. McSween's team found a spiral structure running through magnetite crystals in ALH84001. On Earth, such structures are found in magnetite crystals that form in volcanic vents at temperatures of 900° to 1,600° F. Life as we know it could not survive in those conditions, a fact that McSween and his colleagues say casts major doubt on the possibility of past life in ALH84001.

David McKay of NASA's Johnson Space Center, leader of the NASA team, counters, "The magnetites that McSween, Harvey, and Bradley saw and published pictures of are not really much like the ones we analyzed. By no means is this completely settled one way or the other. I'm a little irritated that on the basis of one paper, people are pronouncing life on Mars dead, whether it's the authors or the media. It is very complex and there are no simple, easy answers. My own personal opinion is that we'll have to bring samples back from Mars before there will be a definite answer one way or the other."

Seeing the Edges of Black Holes

For the few doubters that remain, more evidence is accumulating that black holes are for real. A team from the Harvard-Smithsonian Center for Astrophysics has reported evidence for the existence of event horizons, the outer boundaries of black holes. The event horizon is defined as the region within which nothing — not even light — can escape. Anything that crosses a black hole's event horizon has a one-way ticket to oblivion.

The Harvard team, led by Ramesh Narayan, bases its conclusions on observations of X-ray novae, X-ray-emitting binary stars consisting of a normal star and an invisible collapsed object (either a black hole or a neutron star). The powerful gravity of the collapsed object draws gas from its stellar companion, forming an accretion disk around the collapsed object. According to Narayan's team, gas in the disk heats up to temperatures of one trillion kelvins. The gas eventually spirals into the collapsed object. If the gas hits a neutron star, the collision will unleash a torrent of X rays. But if the gas runs into a black hole's event horizon, it suddenly disappears from the universe.

Observations of nine X-ray novae by the Japanese X-ray satellite ASCA show that in the five systems where the collapsed object appears to have less than three solar masses, the maximum mass of a neutron star, there is lots of X-ray emission. But in the

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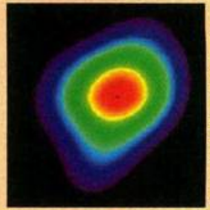
Another Pulsar Planet

Penn State University radio astronomer Aleksander Wolszczan reports that a fourth planet orbits the pulsar B1257+12. The first three planets orbit within 0.5 AU from the pulsar and have minimum masses between that of the moon and 3.4 Earths. The fourth planet has a mass roughly one-third that of Jupiter and orbits at a distance of about 40 AU (Pluto's average distance from the sun). At that distance, it takes the planet about 170 years to complete an orbit.

Imaging Gamma Rays Sharply

Astronomers using the Gamma-Ray Arcminute Telescope Imaging System, or GRATIS, have achieved the first arcminute resolution images of the gamma-ray sky. Focusing gamma rays is difficult because of their very high energies, which cause them to pass right through traditional optical instruments. GRATIS flies on a high-altitude balloon platform to get above Earth's absorbing atmosphere and takes images with ten times better resolution than previous gamma-ray instruments.



Columbia Univ., Lawrence Livermore, and UCSB

The sharpest gamma-ray image yet of the source GRS 1915+105.

Primeval Galaxies Galore

Using a clever technique to distinguish extremely distant galaxies from the foreground variety, a team led by Caltech astronomer Chuck Steidel has found 140 primeval galaxies. Many of the galaxies are so far away that we see them as they existed less than 2 billion years after the Big Bang. "For the first time, it is possible to assess, in a general way, what very early galaxies were like, and how they were clustered in space," says Steidel. The results imply that galaxy formation was just getting started a few billion years after the Big Bang. The galaxies appear to be arranged in large-scale structures.

Shakespeare-Astronomy Connection?

According to Pennsylvania State University astronomer Peter Usher, William Shakespeare's play Hamlet symbolizes the triumph of the sun-centered solar system model. Usher claims to have found numerous veiled references to astronomy in Hamlet. "For example, the slaying of Claudius at the end of the play signals the demise of the Ptolemaic Earth-centered model," says Usher. Usher says Shakespeare veiled the astronomy references to avoid offending religious and political authorities.

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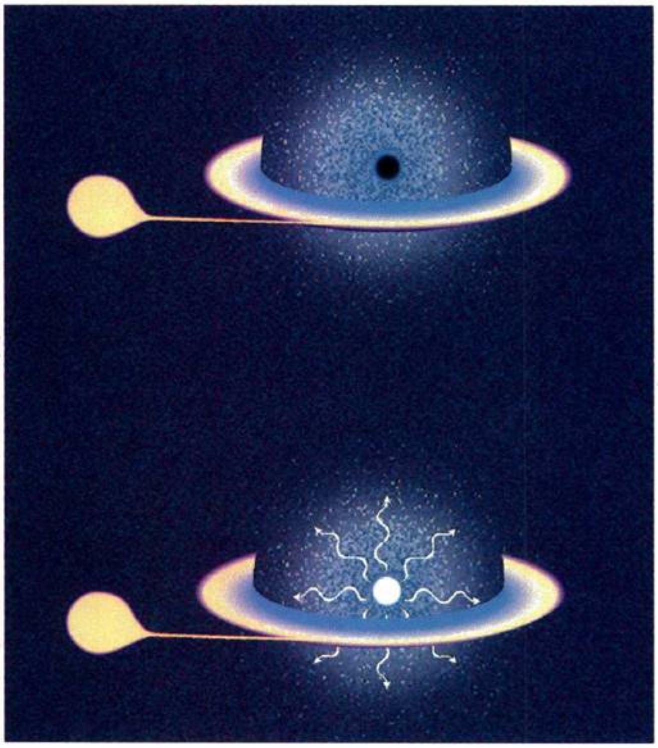


Ramesh Narayan (Harvard-Smithsonian Center for Astrophysics)

If an accretion disk's gas runs into a black hole, it disappears inside the black hole's event horizon and produces little X-ray emission. But if the gas runs into a neutron star, it emits a torrent of X rays.

four systems where the collapsed object weighs more than three suns — making it too massive to be a neutron star — the X-ray emission is minimal, as if the gas in the accretion disk suddenly vanishes. Narayan cites one of the systems in particular, V404 Cygni: "This star seems to be swallowing nearly 100 times as much energy as it radiates. The only way this can happen is if the star is a true black hole."

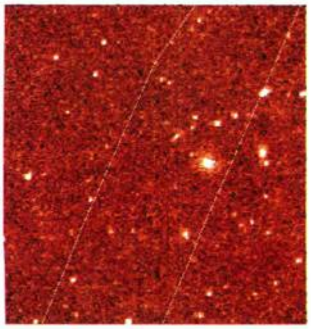
Gamma-Ray Bursts from Afar

Three decades of observations have yet to resolve some of the most basic questions surrounding gamma-ray bursts. Even the distances to these enigmatic events remain totally unknown. Some astronomers believe that they occur in the outskirts of our galaxy while others argue that they arise in the far reaches of the universe.

Two new studies, however, strongly suggest the bursts originate in the distant universe. The first, conducted by Charles Meegan of NASA's Marshall Space Flight Center and his colleagues, looked at the distribution of more than 1,700 bursts and compared it with predictions made by models that place the bursts in or just outside our galaxy. The team concluded that "gamma-ray bursts are about 300 times more likely to come from the far edge of the universe than from our own galaxy or the halo that surrounds it," says Meegan.

In the second study, Samuel Larson of UCLA and his collaborators tried to locate galaxies in the vicinity of gamma-ray bursts. Unfortunately, the burst locations are not known precisely. Using data from the Burst and Transient Source Experiment on the Compton Gamma-Ray Observatory and from interplanetary spacecraft, the team could narrow the region of sky from which individual bursts arose. However, dozens of potential host objects still remained in those regions. "It's a classic needle in a haystack problem," says Larson, "with the added twists that we don't know what the needle looks like or where the haystack is located."

The team took infrared images — 100 times more sensitive than previous studies — of gamma-ray burst locations and found about twice as many galaxies in those fields than in other areas. "Although it may be coincidental," says Larson, "the profusion of galaxies suggests that they may have been the hosts for the bursts."



Samuel Larson (UCLA)

Gamma-Ray Burst 920720 occurred somewhere within the region outlined, which also includes a bright, extended galaxy. A team of astronomers has found that gamma-ray bursts tend to lie in regions containing more galaxies than would normally be expected, supporting the idea that the bursts arise in galaxies in the distant universe.

HET Project/Thomas A. Sebring

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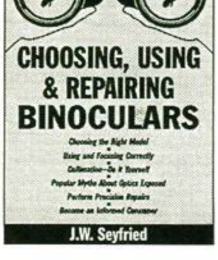

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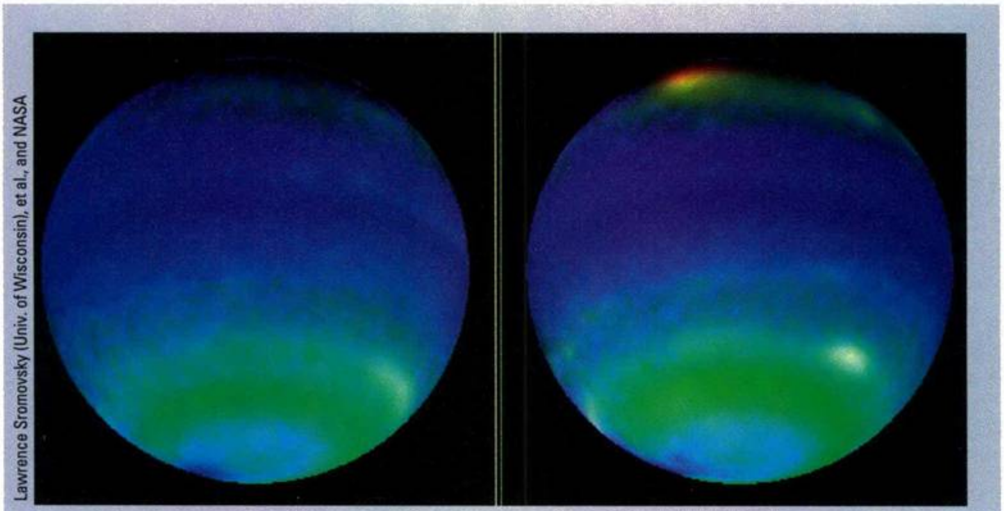

Lawrence Sromovsky (Univ. of Wisconsin), et al., and NASA

With no spacecraft currently en route to Neptune, the Hubble Space Telescope can keep an eye on our fellow planet. Here we see remarkable detail in Neptune's upper atmosphere. University of Wisconsin astronomer Lawrence Sromovsky and colleagues assembled these images by combining information from different wavelengths of light. The planet's bluish cast comes from methane, which absorbs red and infrared light. The white features are clouds of methane ice high above most of the atmosphere. The highest clouds of all are the orangish clouds of methane ice seen at the top of the image on the right. The dark blue belt just below Neptune's equator is the powerful equatorial jet, where wind speeds top 850 miles per hour. These images are frames from a movie that covers Neptune's entire 16.11-hour rotation. If your computer can view MPEG movies, check out the web site http://www.stsci.edu/pubinfo/PR/96/33.html.

The Hobby-Eberly will be used primarily for spectroscopy. Among other things, astronomers will study extrasolar planets, black holes, dark matter, the early universe, and the chemical makeup of the Milky Way Galaxy. The first science results should be in hand by late 1997.

Although the Hobby-Eberly Telescope has a larger primary mirror than those of the twin 10-meter Keck Telescopes in Hawaii, the Kecks are still considered the world's largest optical telescopes. The Hobby-Eberly Telescope's primary mirror has a fixed declination. To look at objects with different declinations, controllers aim secondary mirrors. But this means astronomers can't take full advantage of the 11-meter aperture at any given time, giving the telescope an average effective aperture of 9.2 meters.

Comet Hyakutake's Interstellar Roots

Last spring's monster comet might be a chip off the interstellar block, so say astronomers who discovered acetylene gas in the region surrounding Hyakutake's nucleus. Not only that, the compound was found in the same relative abundance astronomers think exists in ice particles in interstellar dust clouds. Earlier results revealed two other organic compounds — hydrogen isocyanide and hydrogen cyanide — were also present in the same relative amounts that exist in interstellar dust clouds.

The astronomers suggest that the ices found in Hyakutake didn't form with the early solar system 4.6 billion years ago, but that they formed much longer ago in a region of interstellar space. The finding also raises the intriguing possibility that some of the water incorporated into the early Earth originally came from the depths of interstellar space and did not condense in the outer regions of our solar system's protoplanetary nebula.

Information like this has never been gleaned from a comet. Hyakutake's unusually close, nine-million-mile flyby of Earth in March 1996 let scientists train supersensitive detectors on the comet. Most comets lie too far away from Earth to fall under such scrutiny. Only studying a comet close-up with a spacecraft would yield significantly better results. Such an opportunity might come when NASA's Deep Space-1 encounters Comet West-Kohoutek-Ikemura in June 2000.

Jupiter Took Its Lumps in 1690

Almost three years ago scientists and backyard observers alike were treated to the Great Comet Crash. For one week, 20 fragments of Comet Shoemaker-Levy 9 dug deep into Jupiter's cloud-tops and exploded to leave Earth-sized pockmarks. Such an event, we were told, only happens every few thousand years or so.

Now a Japanese researcher has found evidence that Jupiter suffered a similar bombardment a little more than 300 years ago. For the better part of two years, Isshi Tabe sifted through the archives of the world's observatories. He was looking for any drawings or observations that matched what astronomers saw during the 1994 crash. Although some candidates turned up, they lacked significant details that related them to what astronomers witnessed with S-L 9.

Then Tabe came across a series of drawings made by the famous Italian astronomer Giovanni Cassini between December 5 and December 23, 1690. They show a spot on Jupiter growing from a round, dark splotch to an elongated streak splayed across 29° of jovian longitude. Cassini's observations of a single impact

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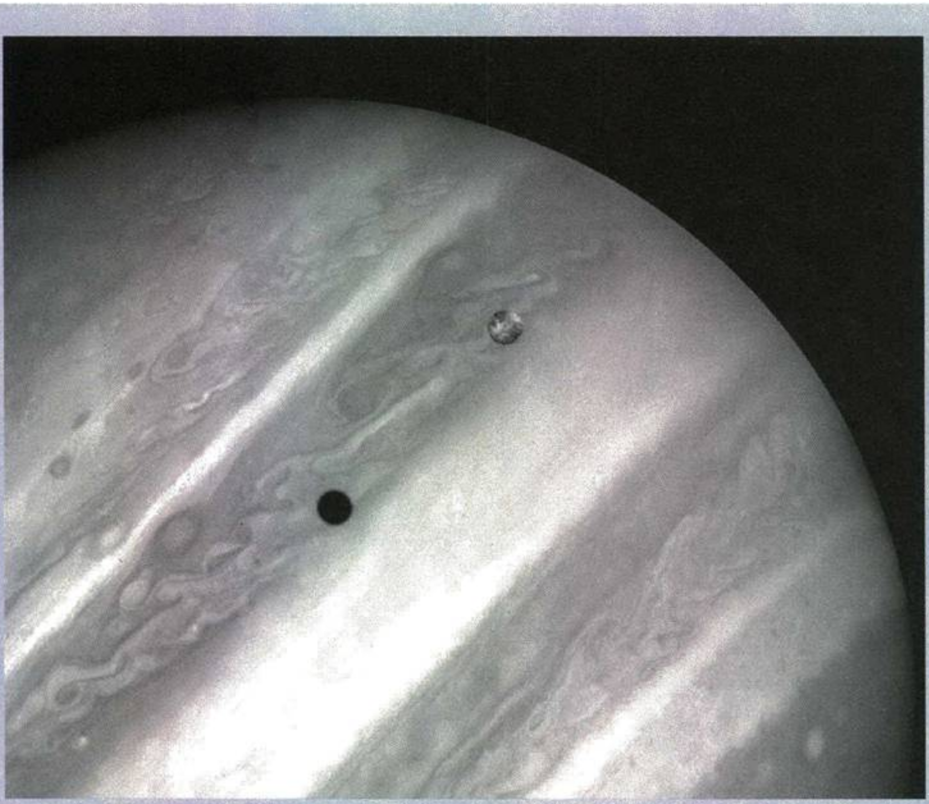
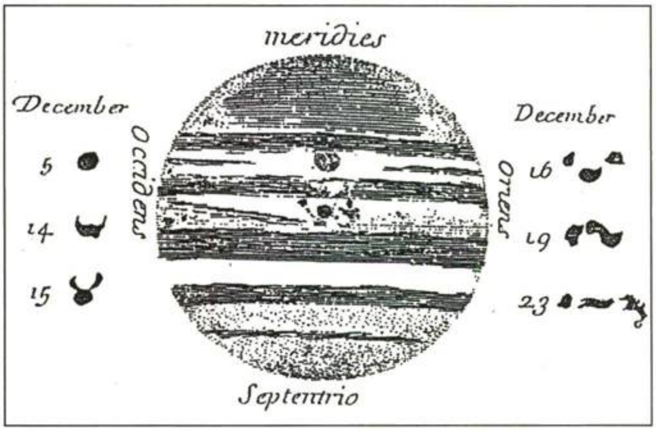


John Spencer (Lowell Observatory) and NASA

Jupiter and its volcanically active moon Io are captured in this Hubble Space Telescope photo. The black spot on the planet is Io's shadow. To get an idea of Jupiter's immense size, consider for a moment that both Io and its shadow are roughly 2,260 miles across, about the distance between New York City and Houston, Texas. Despite the fact this photo was taken from Earth orbit, Hubble's remarkable resolution enables us to see details only 100 miles across. The bright patches on Io are regions of sulfur dioxide frost (sulfur dioxide is the stuff that smells like rotten eggs). Hubble images are being used to complement the much closer images taken by the Galileo spacecraft.



Isshi Tabe

In a preview of 1994's Great Comet Crash, the Italian astronomer Giovanni Cassini apparently recorded a hit on Jupiter that happened in 1690. Japanese researchers found his drawings in the archives of the Paris Observatory. They show how the impact spot's appearance changed over the course of 18 days.

echo how 4 of the 20 impact sites on Jupiter evolved after the '94 crash.

Junichi Watanabe of Japan's Okayama Astrophysical Observatory took the analysis even further. He ran a computer simulation of how a spot the size Cassini recorded should change over time. His model folded in our current understanding of jovian atmospheric dynamics, based upon wind data gleaned from two Voyager spacecraft flybys in 1979. The model's predictions line up very closely with what Cassini saw through his telescope.

"This discovery reminds us of the importance of data archives," says Watanabe. "We should carefully preserve astronomical data for future generations of astronomers." Watanabe and Tabe plan to continue their search for other Jupiter impacts hidden in the pages of recorded history.

Biggest Telescope Mirror Cast

The first of two mirrors destined for the Large Binocular Telescope was successfully cast at Steward Observatory's Mirror Laboratory in January. At 8.4 meters (27.5 feet) in diameter, it ranks as the largest single-piece mirror ever attempted. Using a honeycomb design pioneered by Steward's Roger Angel, the mirror will weigh a little more than 17 tons, just one-fifth of what a solid mirror of the same size would weigh.

Starting January 12, the Mirror Lab team began heating blocks of glass in a mold. The furnace eventually reached a temperature of 2,165° F (1,180° C) on January 19. The glass, then the consistency of honey, flowed through the mold, which was spinning at 6.8 rpm. It then took about 12 weeks for the mirror to cool and anneal.

The mirror will form one-half of the Large Binocular Telescope on Arizona's Mount Graham. The pair will have the light-gathering power of a single 11.8-meter mirror and the resolving power of a 22.8-meter telescope. It will offer unmatched sensitivity for observing and imaging faint objects. □

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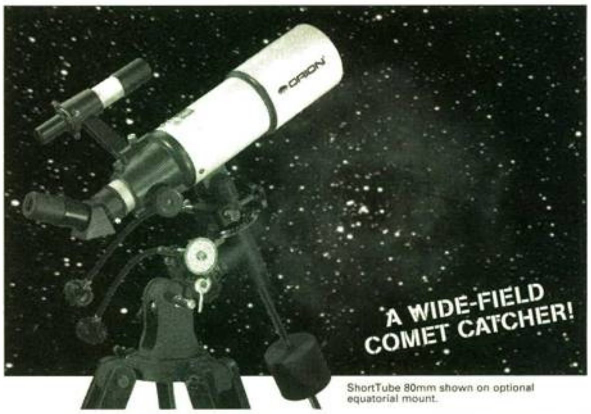

ShortTube 80mm shown on optional equatorial mount.

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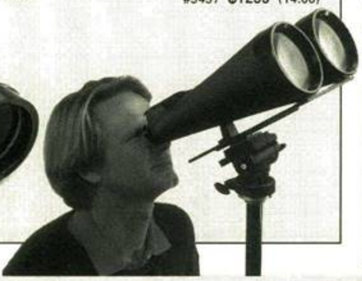

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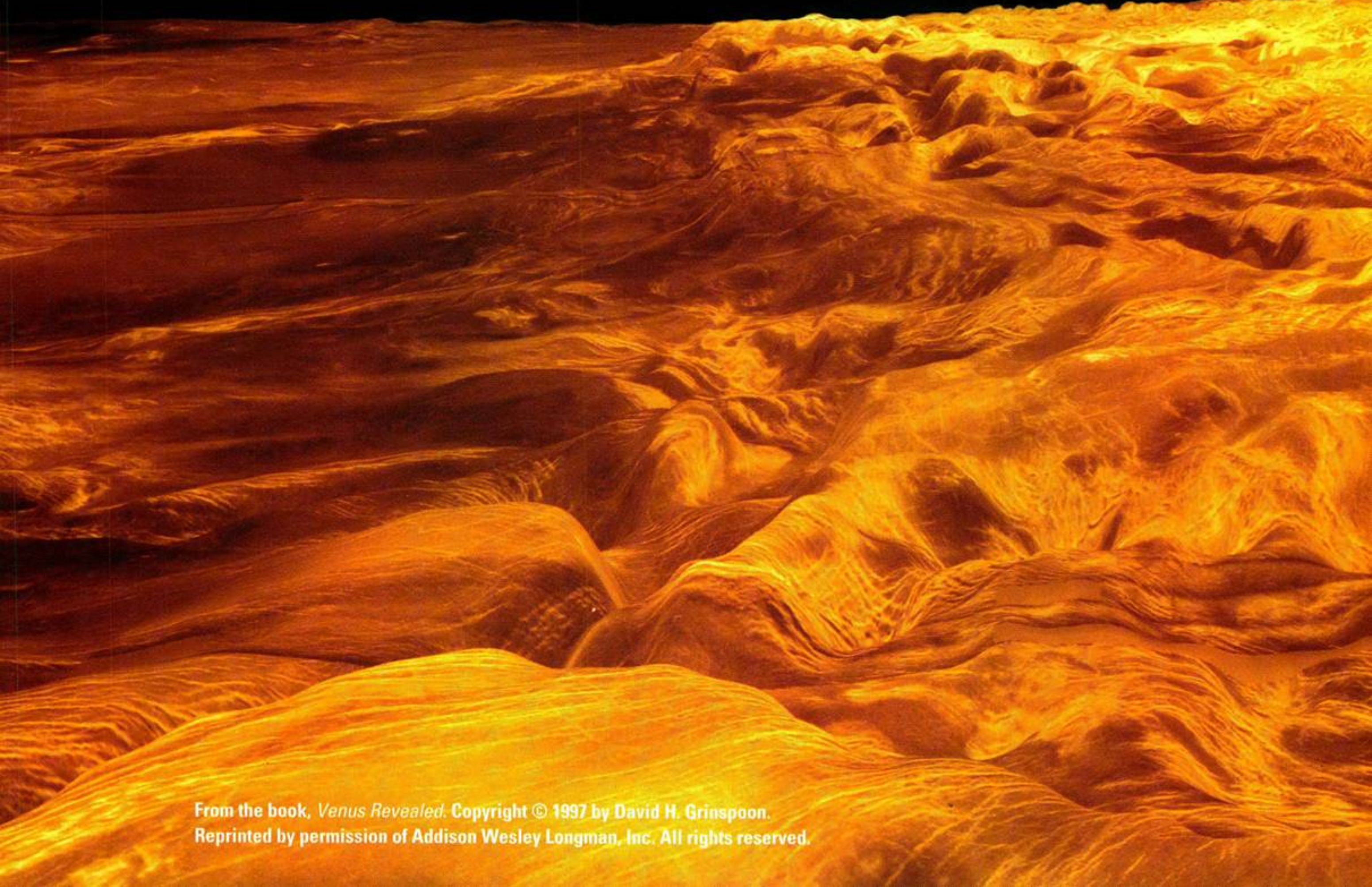
Venus Unveiled

A great volcanic flood must have resurfaced Earth's sister world some 600 million years ago.

by David H. Grinspoon



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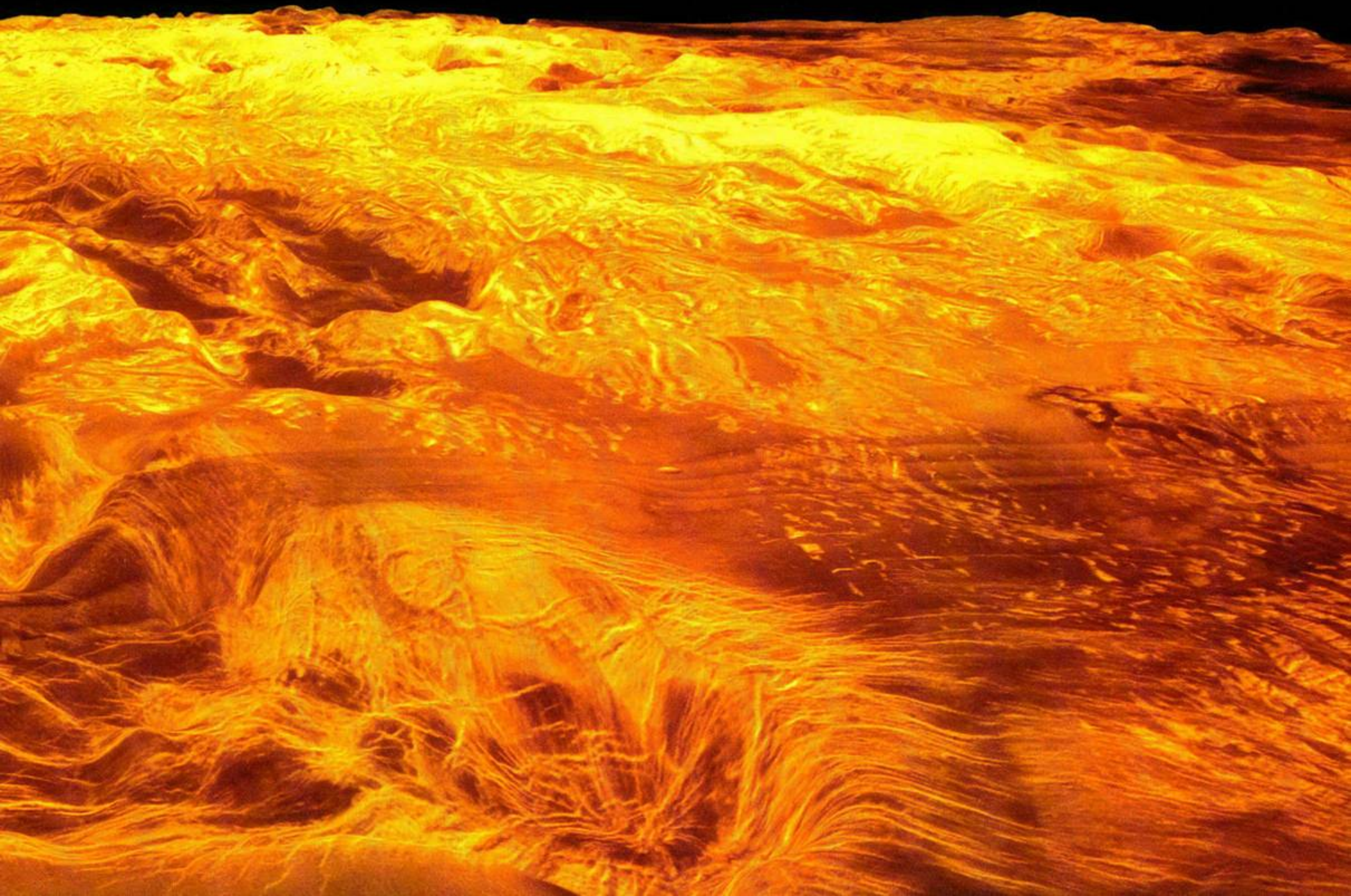
No human eye has ever gazed on the surface of Venus. A thick overcast of impenetrable clouds hides the surface from view. For planetary scientists trying to piece together the planet's history, this poses a distinct problem: Impact craters are the prime chronicle of that history, but if the craters can't be seen, they can't be interpreted either. Because the size and mass of Venus closely match those of Earth, many scientists speculated that the two also had similar histories.

Fortunately, although the venusian clouds are opaque to visible light, radar easily penetrates them. In the 1970s and '80s, the Soviet Venera and American Pioneer spacecraft made coarse radar maps of Venus's surface. But it wasn't until the early 1990s, when the sophisticated Magellan radar mapper went into orbit around Venus, that scientists could clearly see impact craters. Once Magellan had mapped most of the surface, planetary scientists could study the global distribution of craters and look for clues to the planet's history.

In rural areas of the United States, where guns are commonplace and youth are bored, you can roughly date road signs by the number of bullet holes found in them. The older signs are more shot up. It's the same with craters and planetary surfaces. Impact craters are found nearly everywhere in the solar system; they are the universal chronometers of planetary science. In the absence of other processes, a planet



will gradually accumulate craters from the random impacts of asteroids and comets. Astronomers know fairly well how many of these stray bodies exist and how often they hit planets, so crater density can be used to calculate the age of a surface. In Magellan images of Venus, just over 900 impact craters have been counted, which corresponds to an average age of half a billion years, give or take a couple of hundred million. This makes it by far the youngest planetary surface in the inner solar system, except for Earth's.

Comparing the crater density in different areas and different types of terrain helps planetary scientists assemble a historical sequence for a planet. Older, less active areas will have collected more craters, while craters have been wiped out on younger, more active surfaces. For example, the relatively young northern plains of Mars are much more sparsely cratered than the ancient southern highlands. This technique works great on most rocky planets. It has helped us learn the history of Mars and the moon. But it doesn't work on Venus.

Venus is "impact challenged." Its surface lacks small craters. It's easy to see why if you imagine standing in a few inches of water and throwing rocks of different sizes down at the sand beneath the water. With pebbles, you can't make a dent in the sand below because the water slows them down and they fall gently to the bottom. A large boulder that you can barely lift will make a nice little crater because the water can't stop it. Now if you change the depth of water, you change the critical size between rocks that can and cannot make craters. The more water, the bigger the rock you need. Similarly, the thicker a planet's atmosphere, the larger an incoming object has to be to survive its high velocity passage through the air and make a crater. Every planet that has an atmosphere has a cutoff size, depending on the atmosphere's thickness, below which there are no craters on the surface.

On Venus, the smaller impacting objects that would otherwise do most of the cratering are filtered out by the thick atmosphere. They burn up or explode before they hit the ground, just like meteors do on Earth. On Earth, only dust and pebbles get snuffed (making "shooting stars"), but on Venus you don't get any craters smaller than about two miles across.

Any well-cratered planetary surface has many more small craters than big ones, because there are many more small stray objects in space than big ones. Although these holes are rather small, we have to count them all. The overall peppering of Mars and the moon with very small craters is what allows planetary scientists to determine the relative ages of different areas. But because Venus has no small craters, they can't help determine the planet's chronology. All areas have more or less the same small number of craters. Although some minor variations in crater density exist from place to place, these are of the kind that we would expect to be produced by the blind marksman of impact cratering. A global map of craters on Venus is indistinguishable from a random pattern.

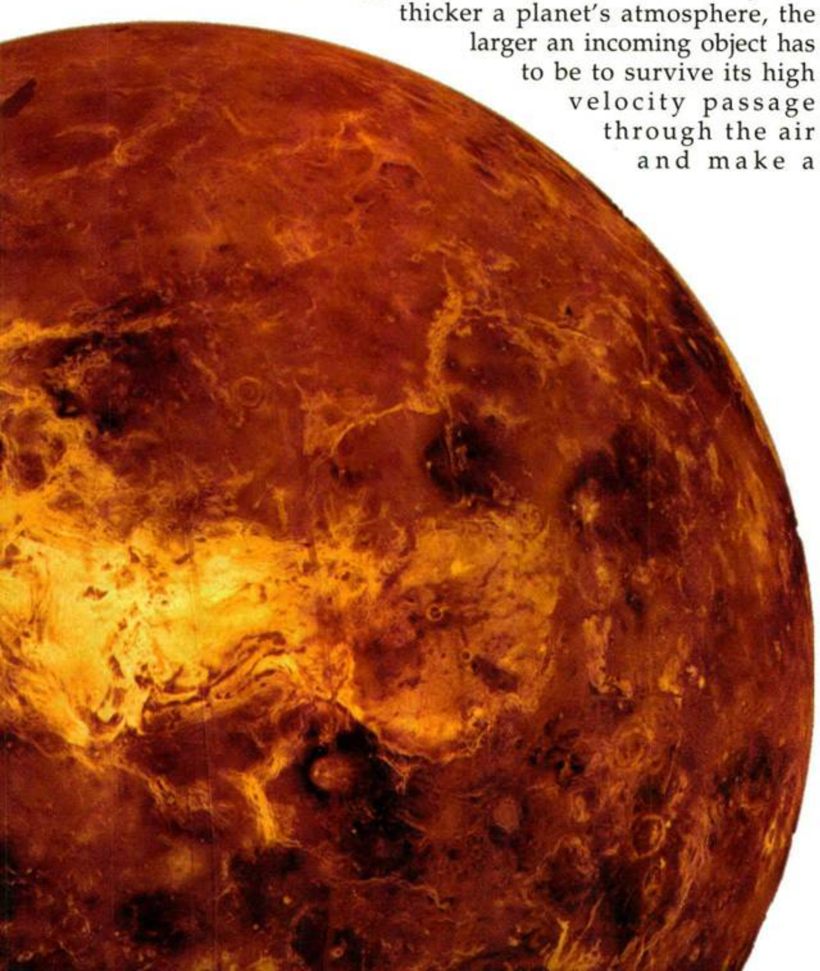
It turns out to be tough to reconstruct a history for Venus, at least using images taken from orbit. Many of the usual techniques just don't work. Crater counting is out, and erosion is pretty much useless because basically nothing is eroded. (On Mars older features are noticeably more heavily sandblasted by wind and buried by dust than younger ones.) So planetary scientists must rely on other means to assemble a chronology of the surface. In some places it is obvious, on a local scale, that a particular flow or episode of faulting came earlier or later, but efforts to construct a global history have been controversial. For example, it is clear in individual locales that the tesserae — rugged, deformed highland mountains — predate the smooth plains, which lap up onto them. But does this mean that *all* tesserae are older than *all* plains, everywhere around the planet? On any other planet we could just count craters and find the answer. On Venus, we must coax the answers from more subtle clues.

There's another reason why the history of the venusian surface has been tricky to decipher. The first clues to this bizarre history came when planetary scientists noticed that something is not quite right about the impact craters.

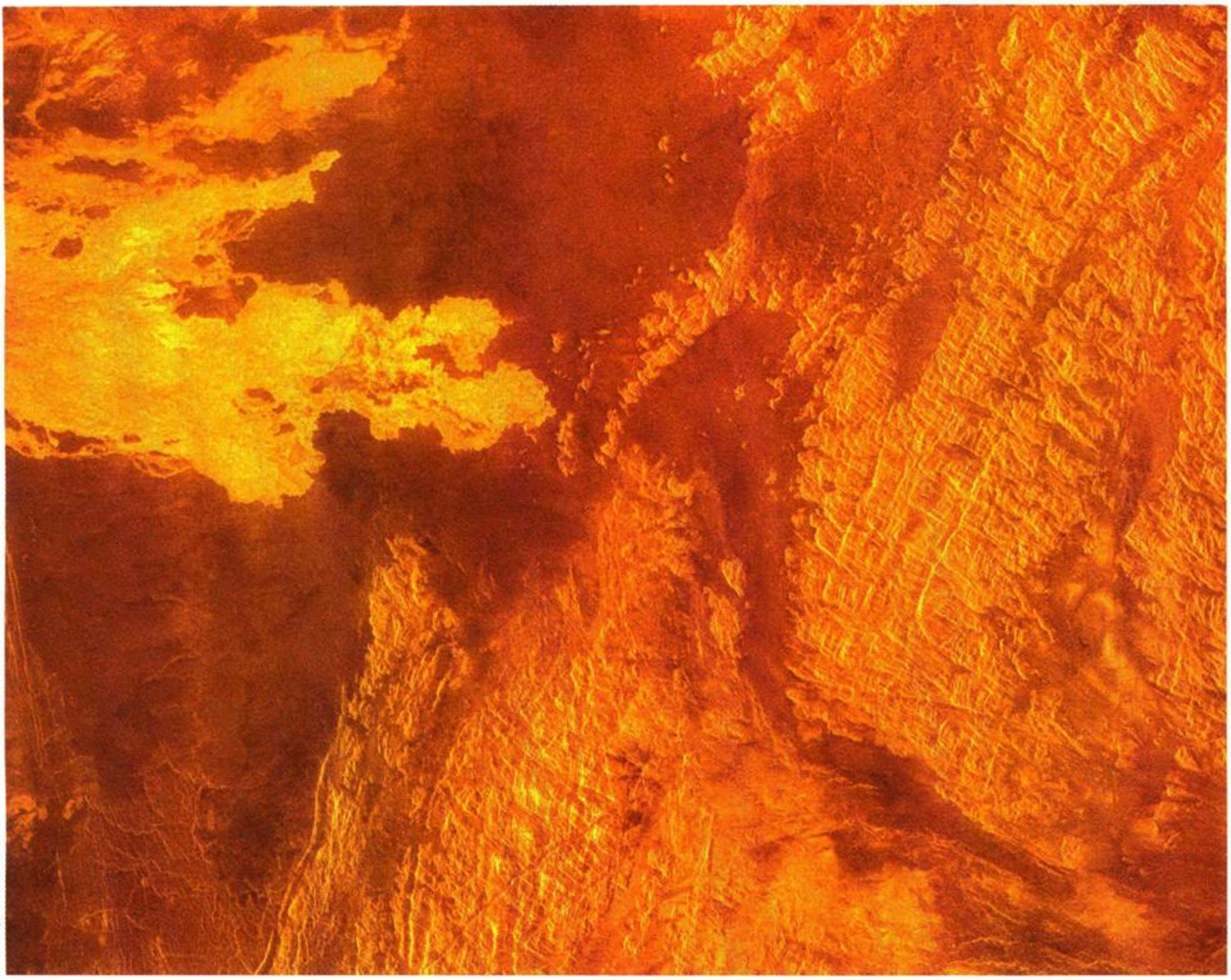
What's Eating the Craters of Venus?

All the craters on Venus look unnaturally pristine. Instead of blending into the volcanic plains that cover most of the planet, they seem planted on top as an afterthought, as though a crew had built a cheap movie-set planet and realized at the last minute that they had better throw in some craters.

The total number of craters indicates that the



Magellan provided a global perspective of Venus by mapping 98 percent of the planet's surface. The bright feature at lower left is the highland region Ovda Regio, which covers an area of 3,900 by 1,200 miles and rises some 2 to 3 miles above its surroundings.



All images NASA/JPL

The great planetwide flood shows up clearly in this Magellan image of part of Eistla Regio. The oldest terrain (at right) consists of highly fractured highlands, or tesserae. The plains that surround and embay the tesserae are the remains of the vast lava seas that once covered all low-lying areas. More recent volcanic activity produced the radar-bright flows at upper left.

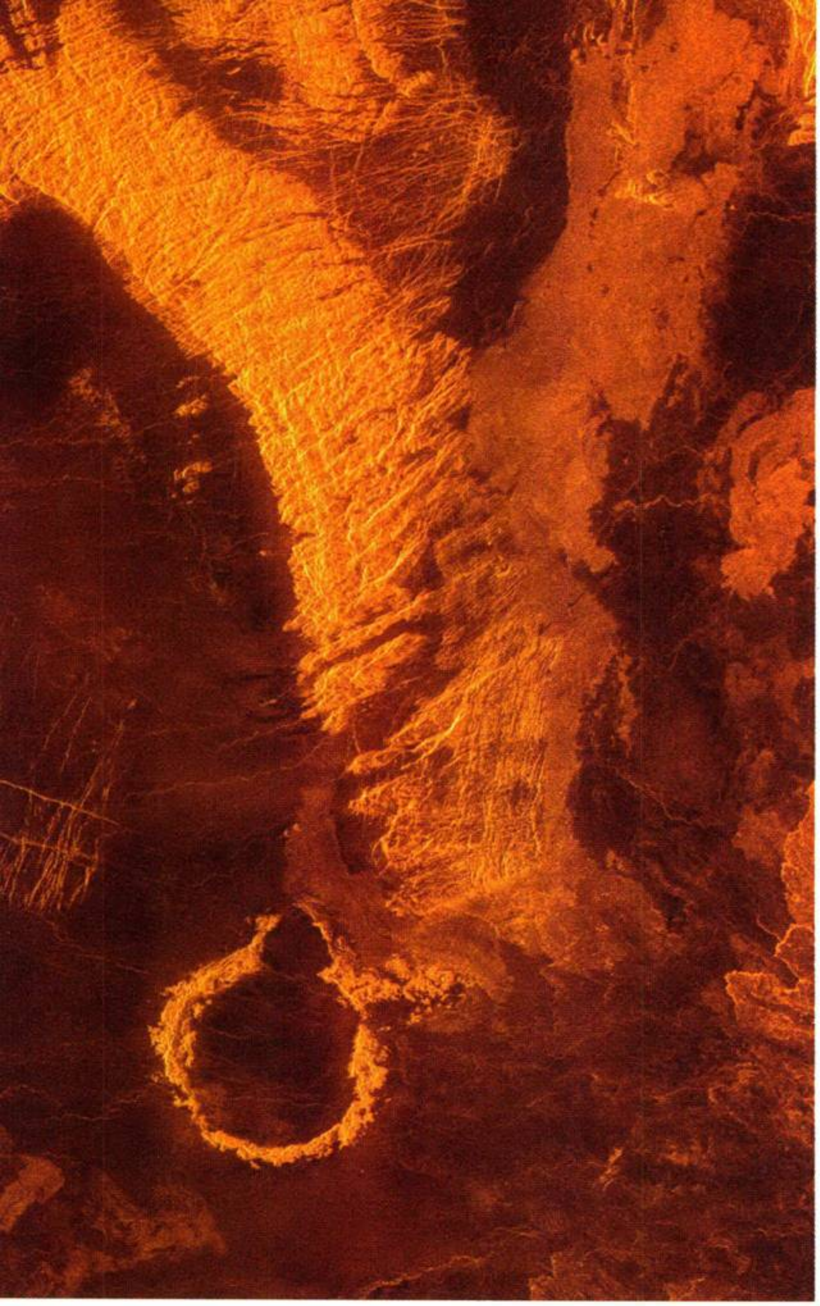
planet's surface is not very old by planetary standards — a billion years, tops. Therefore, some process has removed most of the craters that ever formed on the planet. But there are *no signs* of any such process. The thief who stole Venus's craters has successfully covered his tracks. There are three suspects, but each has a good defense.

If *erosion* were the culprit, we would see a broad range of craters, from pristine fresh ones to highly degraded ones that have nearly disappeared. That's the case on Mars, where erosion by windblown dust is a dominant process.

Craters can also be destroyed by *tectonic disruption*, if they are simply cracked and faulted to the point where they are no longer recognizable. Here again, we would expect to see the process at work, but Venus shows few partially disrupted craters.

A prime suspect is *volcanism*, because volcanic flows dominate the surface. But if craters were being covered by lava, then lots of them should be partially buried beneath the plains. On the moon, for example, the volcanic plains contain craters ranging from those with barely detectable circular outlines that have been almost completely covered by lava to those that are almost pristine but have lava flows lapping slightly up their flanks. On Venus only about 4 percent of the craters are partially covered by volcanic flows, and almost none are mostly buried. This seems to rule out volcanism as a dominant process removing craters. Why, on a planet smothered with volcanic features, are the craters so untouched? Do volcanos on Venus worship craters, as Hindus venerate cows, and thus spare them from their otherwise global carnage? This is not a favored hypothesis, but there has to be a way to explain the odd, and globally pervasive, occurrence of pristine craters overlaying widespread lava plains.

It is as if some mysterious process were swallowing craters whole and leaving no trace. There are a few ways this appearance could come about. If you see a road sign full of holes, it is not necessarily old. Some well-armed fool pumped up on testosterone and booze could have opened fire on it the night before last. What if all the craters really were added as a kind of afterthought, produced by a very recent barrage of impacts? On any planet with reasonable erosion rates, you could test this idea by noticing if some of the craters were worn down, showing signs of age. (Are the bullet holes rusted?) But with little erosion on Venus, you can't tell, so the hypothesis is consistent



A rarity on Venus, the 25-mile-diameter crater Heloise (at lower left) has been largely covered by later lava flows, leaving only the rim showing. Most venusian craters are younger than the flooded volcanic plains, which date to roughly 600 million years ago.

with the way all the craters sit atop the "paint job" of planetwide lava flows.

Unfortunately, this scenario ranks as only slightly more plausible than crater-worshipping volcanos. Everything we know about the inner solar system suggests that there has been no recent burst of cratering activity. Impacting objects do not discriminate greatly among the terrestrial planets. If there had been a recent shower of large meteoroids, we would also see its effects on the surfaces of the moon, Mars, and Earth. We don't.

One scientist suggested that Venus could have had a moon that disintegrated relatively recently, showering the planet with fragments that made most of the craters. Although this theory is hard to disprove, it remains unsatisfying. Scientists don't like to resort to explanations that require extraordinary or fortuitously timed events unless all other possibilities have been exhausted. You can always invent a contrived theory to explain any observation, but the universe in general does not seem designed like a Rube Goldberg machine, and if we dig deeper we can often find simplicity. This preference for simplicity is called Ockham's razor.

Venus Gets a Complete Makeover

Here is another way to explain the unusual crater population: Suppose that half a billion years ago something suddenly happened to Venus, wiping out all older craters. Vast lava flows occurring simultaneously all over the planet would do the trick. Then, if there has been relatively little surface activity since that time and Venus has been slowly collecting craters all along, things should look as they do.

This idea, called catastrophic resurfacing, rubs many scientists the wrong way. Like the disrupted moon theory, it invokes a special event, and quite an incredible one at that. We can hear Ockham sharpening his razor. Some scientists would prefer a steady-state model — one that employs ongoing processes operating at more or less constant rates and that does not require a fundamental change in the planet during the geologically recent past. Many vigorous arguments have been offered in valiant attempts to save us from having to accept catastrophe. Perhaps craters have been steadily destroyed all along by volcanic and tectonic disruptions that are just the right size to destroy whole craters but not partial ones. If small patches of the surface are continually destroyed in this way, eventually the whole surface will be affected and no traces of older craters will be left.

To test these competing ideas, planetary scientists have developed new computer models that simulate the evolution of the surface of Venus. The results have confirmed what seems intuitively correct: If craters are forming at random and are being destroyed by volcanism (which is also randomly occurring over a long period of time), then a lot more craters should be partially covered by lava flows. To return to the bullet-holes-in-road-sign analogy, if someone is going around repainting signs that have been shot up, then holes that have been painted on should be common. If not, the painting must have stopped before most of the shooting. These models seem to support the catastrophic resurfacing theory.

The initially disturbing idea of catastrophic resurfacing became more palatable when it received support from other lines of reasoning. Models of the interior evolution of Venus suggest that the planet oscillates between periods of relative quiescence and periods of instability and rapid surface overturn. In other words, Venus may "freak out" occasionally, getting rid of its internal heat in great planetwide spasms of activity, rather than in the steadier cycling of lithospheric plates that occurs on Earth. These models predict intermittent bursts of greatly enhanced volcanic activity at intervals of several hundred million years. If this scenario is true, the observed crater population could simply reflect the accumulation of impacts since the last time Venus turned inside out.

The initial proposal of the catastrophic resurfacing model drew strong reactions, for and against, from many planetary scientists. Several years of frustrating debates had two sides repeating the same arguments, and it wasn't clear that anyone was listening. Perhaps the community became briefly stuck in this cul-de-sac because of the power of the loaded word *catastrophic*. It recalls the conflict between catastrophic and uniformitarian views of Earth history. Geologists have spent much of the last several centuries demonstrating that surface features on Earth can be explained without recourse to a biblical flood. Must we now accept that much of Venus's surface was created in one great volcanic flood of similar proportions? The search for a steady-state model to explain the craters of Venus can be seen as an attempt to find a uniformitarian alternative. Perhaps the choice of the phrase "catastrophic resurfacing" was unfortunate, and "sudden global resurfacing" would have provoked a more constructive debate (although it does not sound as scientific).

The repetitive debate seems to have largely died down, to the great relief of most Venus scientists. Although some controversy continues, the community seems to be converging toward an acceptance of something like catastrophic resurfacing (although not everyone calls it that). Roughly 600 million years ago, Venus seems to have been wiped clean of craters. Some combination of widespread volcanic flooding and tectonic disruption created a tabula rasa for later cratering. Most of this activity died down quickly, producing a planetary surface that may be nearly all the same age. But planets are never this simple. Even if Venus did receive a near-complete makeover 600 million years ago, any complete picture must include the greater complexity inevitable in an Earth-sized planet.

A lower rate of volcanism and tectonic activity has continued in certain areas to the present day, producing the small number of flooded and disrupted craters. Several lines of evidence support this, including fresh flows on some volcanos, particularly the large shield volcanos (although the lack of erosion *could* fool us into thinking older flows are fresh), and the nonequilibrium mix of atmospheric gases, with an excess of sulfur dioxide probably supplied by active volcanos.

Newer, more detailed analysis of the global crater distribution also points toward more recent surface activity. Although no large areas of lower or higher crater density can be found, some *types* of terrain have more craters than others. For example, the large volcanos have fewer craters than other areas: they seem to be, on average, only half the age of the global plains. The highly deformed tesserae are apparently the oldest areas of Venus. They may be the only remnants of the surface that existed *before* catastrophic resurfacing — high-altitude "islands" that escaped the global volcanic flooding. If so, then perhaps they should have more craters than other areas. This is hard to prove, however, possibly because craters are hard to pick out on images of these highly cracked and wrinkled surfaces. Compared with the smooth plains, searching for craters on the tesserae is like playing "Where's Waldo on Venus?" Many distracting details make it hard to find what you are looking for.

Venus seems to have changed not only its rate of volcanism but its style, fairly abruptly, around 600 million years ago. Before then the planet was vigorously repaving itself with vast plains of basalt. Then, for reasons we don't understand but that must be related to the evolving interior of the planet, it switched over to a lower rate of volcanism, concentrated in specific areas where hot spots forced up broad domes in the lithosphere, creating giant shield volcanos.

If this general picture holds up, the implications for the evolution of Venus are staggering. To cover up all preexisting craters, an episode of rapid volcanism would have had to flood most of the planet's surface with lava to a depth of three to six miles. This implies a rate of volcanism 50 to 1,000 times higher than the recent rate, depending on how long the activity lasted.

Once again planetary scientists are forced to accept that some aspects of planetary evolution have been anything but uniformitarian. Our recently increased appreciation for the role of large impacts in planetary origins and evolution should make this easier to swallow. But large impacts are outside invaders; whatever wiped out the surface of Venus came from within.

Unfortunately, there was no one around to see what Venus looked like during the great flood. But with the detailed views provided by Magellan and the ingenuity of planetary scientists, we can be confident that it did occur. □

David H. Grinspoon is a planetary scientist at the University of Colorado in Boulder.

Ovda Regio, an area of complex ridge terrain, or tesserae, lies at the lower right of this Magellan composite image. The dark areas scattered across the plains to the left of Ovda Regio are very smooth deposits associated with large impacts.

At the Heart of the Lagoon

Ultraviolet radiation and colliding winds form eerie structures in the Lagoon Nebula's central regions.

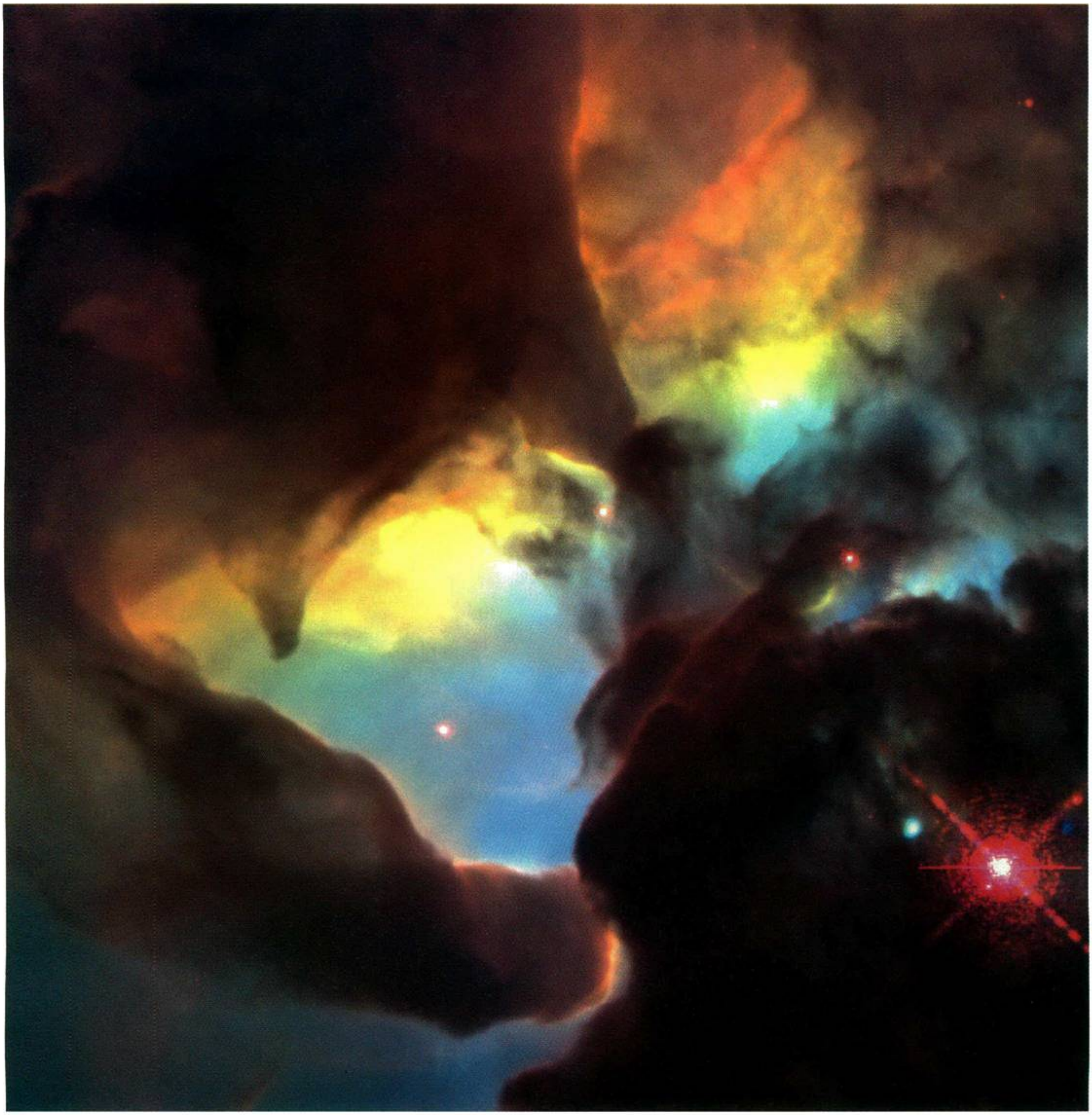
The Lagoon Nebula (M8, NGC 6523) is one of the most widely-photographed objects in the night sky. But despite the familiarity of this beloved nebula, the ultra-sharp eye of the Hubble Space Telescope adds a whole new dimension, revealing an eerie realm of mist, knots, and tornado-shaped structures.

The Lagoon Nebula is a giant stellar nursery located about 5,200 light-years away in the constellation Sagittarius. The nebula is roughly 120 light-years across. Hubble, from its perch 360 miles above Earth, peered deep into the heart of the Lagoon in July and September 1995, zooming in on the region surrounding the Hourglass, the two bright patches at the very center of the nebula. "The level of detail revealed by Hubble was rarely obtained before for a massive star-forming region," says astronomer Adeline Caulet of the Space Telescope-European Coordinating Facility.

The supermassive O star, Herschel 36 (the brightest star in the the image on the facing page), pumps out enormous quantities of ultraviolet radiation. This nasty blast of high-energy radiation slams into the surface of the surrounding nebula. The radiation heats the cold gas to temperatures hotter than the surface of the sun. "It's like taking a blowtorch and holding it to a block of ice," says Arizona State University astronomer Jeff Hester.

This heating generates tremendous disturbances in the nebula, creating powerful winds that transport material away from the inner region of the nebula. This process, known as photoevaporation, has swept away much of the material in the Hourglass. In other words, Herschel 36 is engaging in matricide, killing the nebula from which it was born.

Photoevaporation also sculpts the gaseous pillars in the Eagle Nebula (M16), made famous by a spectacular Hubble photo released in late 1995. Hubble is showing that the same processes occur in a variety of star-forming environments. "This is now taking what started out as a quick-look spectacular image or two of M16 and the Orion Nebula and leading it down the path of solidifying the science, of taking what was a discovery mode activity and turning it into a science activity," says Hester.



Adeline Caulet (Space Telescope-European Coordinating Facility, ESA) and NASA

The Hubble Space Telescope reveals astonishing detail in the Lagoon Nebula's inner region. The largest "twister" is half a light-year long and a mere one-eighth of a light-year wide. Ultraviolet radiation from the supermassive star Herschel 36 (the bright star with the red halo) sweeps out material in the Hourglass. The star's powerful wind helps sculpt the complex structures. The ground-based telescope image on the facing page (top) was taken by Mike Sisk.

The Lagoon's inner region, however, is a far more complex place than the Eagle's pillars. The photoevaporative winds collide with Herschel 36's furious stellar wind, forming the menagerie of structures seen in the Hubble Lagoon image. In contrast, the Eagle's pillars have no nearby supermassive stars, so photoevaporation is the sole acting agent.

This picture was assembled from three Hubble images taken through narrow-band filters. Hester stresses that the colors are not what your eye would see if you could view the nebula up close. "But they're a lot closer to what the eye would see than your typical color astrophoto," he says. Hester adds, "The purpose of this is not just to make a pretty picture, the purpose is to do good science." — *Robert Naeye*

GOING to extremes

Astronomers brave bone-chilling temperatures and the endless Antarctic winter to look ever-deeper into the universe.

by Beth A. Livermore

Last field season, Doug Lowder did not blink for 18 hours. Instead, he stared at his computer screen like his life depended upon it. In a sense it did. Below him a chain of glass balls dropped into the deepest hole ever drilled at the South Pole. If the balls froze in safely and functioned properly, Lowder's team would be on its way to building the world's first ice telescope — perhaps creating a whole new science. If the globes froze too quickly and shattered, or did not sink deep enough, the season, maybe even the future of his project, would be jeopardized.

Lowder, a physicist at the Lawrence Berkeley Laboratory in California, is just one of many scientists who is pushing the limits to make the United States Amundsen-Scott South Pole station a world-class observatory. Here at the bottom of the Earth they craft highly experimental telescopes, forever tweaking them to accommodate the extreme conditions. Now, from the same polar plateau that lured some of the greatest explorers of the 20th century, astronomers venture to reveal the origin, structure, and fate of the universe.

Beth Livermore

Beth Livermore

Major construction on CARA and other South Pole facilities can only occur during the brief austral summer, which lasts from mid-November to mid-February.

A Virginal Start

The South Pole has long teased curious astronomers. In the 1920s, the University of Chicago's Yerkes Observatory considered Admiral Robert Peary's proposal to place a telescope at the pole to take advantage of some unique benefits. It offers six months of perpetual darkness. Objects south of the celestial equator circle the horizon at constant elevation, so they never set. The South Pole is also drier than the Sahara Desert and colder than parts of Mars. This, coupled with the pole's 9,300-foot altitude, makes for exceptionally dark and transparent skies.

However, for years the challenges of working here eclipsed the potential benefits. To begin with, the South Pole is remote. During the austral summer, a visitor must take at least four flights to get there from the United States. Come winter, there is no way to or from the South Pole. Temperatures can plummet to a bone-numbing –117° F — so cold that refrigerators have to be heated to prevent freezer-burnt food. "You can't work for more than 60 seconds at a time in light gloves," says Yerkes engineer John Briggs, a seasoned visitor. Technical complications like power outages, computer crashes, and frost-encrusted lenses are common. So while astronomers have worked here for more than 30 years — since Martin Pomerantz's cosmic ray studies in the 1960s — their presence was limited. Facilities consisted of Quonset huts that were built and broken down each season.

A string of neutrino detectors is dropped into a 1.5-mile-deep hole.

Bruce Koci/AMANDA

But at the dawn of this decade, scientific advances made the idea of establishing a permanent year-round observatory at the South Pole irresistible. In 1991, the National Science Foundation (NSF), an agency funded by the U.S. government, established the Center for Astrophysical Research in Antarctica, or CARA, to build a set of infrared and submillimeter radio telescopes to study wavelengths obscured at most other observing sites. Ten institutions are involved with CARA, which is headed by the University of Chicago.

A year later, the NSF approved the project Lowder works on, the Antarctic Muon and Neutrino Detection Array project, or AMANDA. This group monitors invisible, subatomic particles called neutrinos. AMANDA, which is not officially part of CARA, is headed by the University of Wisconsin and involves seven institutions from the United States, Sweden, and Germany.

Together, these projects may someday answer some of the most vexing questions in astronomy. Roughly 15 billion years ago, moments after the Big Bang, the universe was no larger than the dot that ends this sentence. Most scientists think that all that fills the heavens today sprung from that single "egg." But how did the universe evolve? Why did matter eventually curdle into bands to form the Milky Way and other galaxies? Will the universe continue to expand or will it one day collapse in on itself to form a final, fiery ball? Each of the South Pole projects focuses on different stages and processes of cosmic evolution. Together they will trace the life cycle of the universe from its embryonic beginnings to what might someday be the end.

The Dark Sector

The easiest way to get a handle on the details of a program like this is to visit the research site. In this case, however, that meant three days of travel, survival school, sleeping in an igloo, Diamox tablets, and bureaucracy. The NSF selects journalists and then shuttles them from New Zealand to view their various Antarctic research projects, which include fields such as biology, geology, meteorology, and glaciology. Of the three permanently occupied American bases in Antarctica, the South Pole station takes the fewest non-scientist visitors. Not only is it 840 miles from the main U.S. base at McMurdo Sound, in the austral summer it has a population cap of 175 that cannot be exceeded. If someone flies in, someone must fly out. Non-scientist visitors are only allowed in the summer, when there is constant daylight.

Arriving at the South Pole has been likened to landing on the moon. The snow desert that surrounds the South Pole station is completely devoid of life. The altitude slows both motor and cerebral function. Polar gear makes movement clumsy. When the Hercules LC-130 plane lands on its skis and drops off its passengers on the polar plateau, the sense of isolation can be overwhelming. But once adjusted, it becomes apparent there is plenty of activity here. This is especially true of the Dark Sector.

Bruce Koci/AMANDA

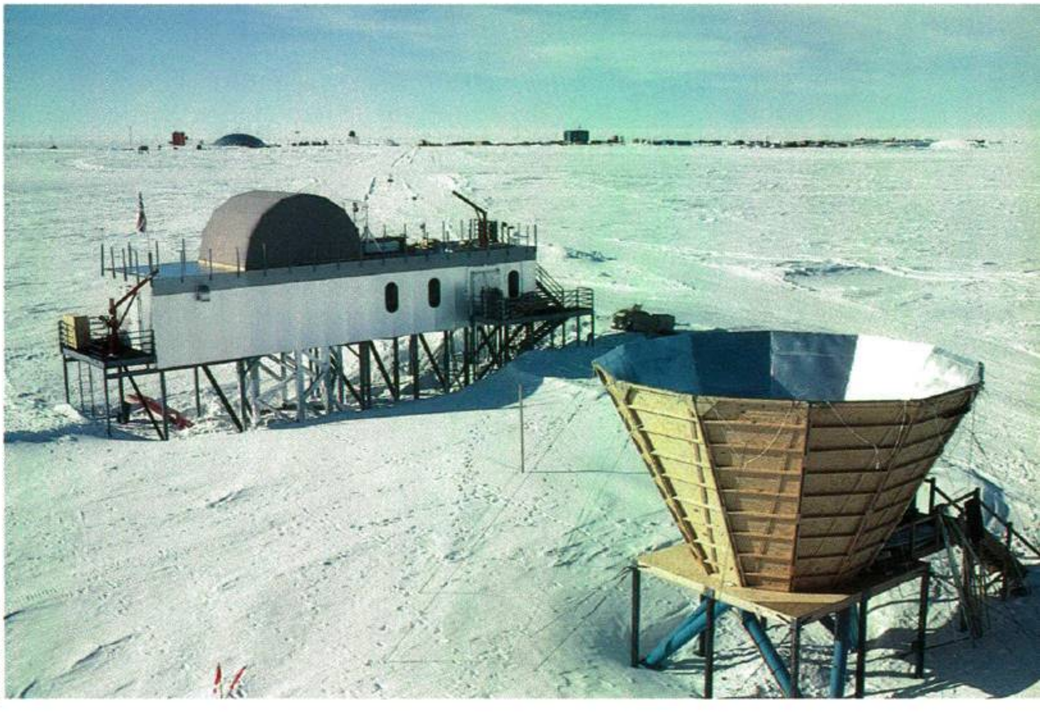
The drilling rig for the AMANDA neutrino experiment uses 200° F water to bore deep into the Antarctic ice cap.

The Dark Sector, which is occupied by a cluster of buildings and a suite of highly innovative telescopes, is located three-quarters of a mile from the main base to minimize light and radio pollution. As you walk out over the snow dunes, the first thing you notice is the 30-inch Python microwave telescope, whose radiation shield gives it the look of a giant funnel on stilts. It is part of CARA's most established project, the Cosmic Background Radiation Anisotropy experiment, or COBRA for short.

Embryonic Skies

The COBRA project aims to map the most primitive part of the observable universe, the cosmic microwave background radiation that formed just 300,000 years after the Big Bang. In effect, scientists hope to reveal the blueprint, or "DNA," from which the rest of the universe has developed.

To do this, they use Python to measure anisotropies, or heat variations, in the cosmic microwave background. These temperature differences, as small as 1/100,000 of a degree, were caused by the uneven distribution of matter in the early universe. The non-uniform gravitational forces arising from these concentrations of matter eventually led to structures that we see in the present universe — including planets, stars, galaxies, and clusters of galaxies. In


Beth Livermore

The 75-centimeter Python microwave telescope sits inside a funnel-shaped radiation shield. The AST/RO building lies in the background. Even though only a few inches of snow fall on the pole each year, it never melts. So buildings and equipment are placed on stilts to prevent burial from drifting snow.

Winter at the Pole

Imagine being surrounded by a frozen, barren wasteland that stretches for hundreds of miles in all directions. The temperature is –70° F and it's getting colder. It's March 21, and the sun has just set. You won't see it again for six months. You'll be completely isolated from the rest of the world until late October with no hope of rescue. Welcome to the South Pole.

Beth Livermore

"In some ways the environment is comparable to outer space, but you amaze yourself with how well you acclimate to functioning there," says Yerkes Observatory engineer John Briggs, who wintered over at the South Pole in 1994. Each year, several CARA staffers spend the winter at the Pole to operate and maintain the telescopes and other equipment. They live at the Amundsen-Scott Station with about 25 other hardy souls who maintain the base and work on other NSF polar projects.

Life is not as unpleasant as it might seem. According to Briggs, the heavy parka, heavily insulated pants, thermal underwear, face mask, gloves, boots, and other winter clothing supplied by the NSF are "more than enough to keep you functioning even on the coldest, windiest South Pole day." Briggs says the food is superb, thanks to an elaborate kitchen and an expert chef.

For entertainment, residents can enjoy a bar, a library, a gymnasium, a lounge with a pool table, videos, and, in the words of Briggs, "a raucous derivative of volleyball." When the outdoor temperature plunges to –100° F (the record low is –117°), the hardiest souls crank up a sauna to 200° F and sit inside for a few minutes. Next, they scamper into the frigid Antarctic night. These people join the "300 Club," experiencing a 300° F change in temperature.

Briggs says the most enjoyable aspect of his stay was the camaraderie that developed amongst the group. Sharing the adventure of harsh conditions helps build strong friendships that last a lifetime. For this reason, many of those who have wintered over at the pole have returned to spend additional winters there.

— Robert Naeye

other words, early clumping made life possible.

So far COBRA has detected more than 100 hot and cold spots in the cosmic microwave background. Its data are among the most precise and best confirmed measurements yet made of intermediate angular scale anisotropies. In fact, it has provided a higher resolution "picture" than the COBE satellite, which first mapped the microwave background in 1992. Later this year, a group led by astrophysicist Jeff Peterson of Carnegie Mellon University will install Viper, a 2-meter telescope that can sweep the sky with even finer resolution to produce more complete images of the microwave sky. "Here the same scientists who make the telescopes do the research," says Peterson.

Early Development

The other two telescopes in the CARA program, AST/RO and SPIREX, stand near Python. AST/RO lies on top of its own laboratory building, which looks like an aluminum cargo box. SPIREX stands on a tower that adjoins the royal blue Martin A. Pomerantz Observatory building, which houses the SPIREX, COBRA, and AMANDA experiments. All of these projects will contribute to the understanding of the universe, but in dramatically different ways.

To begin with, the SPIREX project, or South Pole Infrared Explorer, aims to probe ancient galaxies, galaxies so far away that the expansion of the universe has stretched their visible light all the way into the infrared part of the spectrum. Scientists believe that this will reveal to them what the universe might have looked like in its infancy. The 24-inch SPIREX infrared telescope is laying the groundwork for larger telescopes that can produce detailed images of the sky at wavelengths longer than can be seen with the Hubble Space Telescope. SPIREX has shown that telescopes located on the Antarctic plateau can see deeper at thermal infrared wavelengths than can any other ground-based observatory.

Taking advantage of the darkest near-infrared sky on Earth, it has begun to image nearby galaxies with a sensitivity comparable to those made at visible wavelengths. While looking for faint galaxies in the infrared, the SPIREX team should also be able to find "cold" stars, such as brown dwarfs and old white dwarfs, that emit very little radiation. Future surveys may help determine the extent to which cold stars contribute to dark matter, the elusive material that accounts for at least 90 percent of the universe's mass.

SPIREX made headlines during the summer of 1994 when it caught comet Shoemaker-Levy 9's collision with Jupiter. "The SPIREX team worked hard to get the telescope in place in time, and it paid off," says Al Harper of the University of Chicago, CARA's director. Because Jupiter remained above the South Pole horizon throughout the week when the comet fragments rained down on the planet, SPIREX was able to make the most complete set of images. Only four out of 21 impacts were obscured by clouds.

Mature Insight

Meanwhile the AST/RO project, short for Antarctic Submillimeter Telescope and Remote Observatory, looks at mature galaxies, including our own Milky Way, for a contemporary view of star formation.

It uses a 1.7-meter telescope to catch light in the submillimeter range of the radio spectrum. "This band is blocked by water vapor at other sites," says Antony Stark of the Harvard-Smithsonian Center for Astrophysics. But the stable and relatively transparent Antarctic sky has allowed AST/RO to detect radiation from neutral carbon atoms throughout unexpectedly extensive regions of the southern Milky Way and the Large and Small Magellanic Clouds. The radiation from carbon atoms will provide crucial clues to the physics of star formation.

In the future, the AST/RO team will extend their work to even shorter wavelengths, yielding deeper insight into star formation and interstellar gas. The team is also planning to build a 10-meter telescope that would detect the most distant protogalaxies and galaxy clusters.

An Earthly Filter

Finally, there is the AMANDA project, which resides near the Pomerantz building. Essentially a giant detector made of ice, it will catch neutrinos in order to gain insight into violent processes that occur deep within the nuclei of active galaxies.

Neutrinos are the most abundant particles that are known to exist. But they are massless or nearly massless, and have no electric charge, so they move through the universe like ghosts. Neutrinos may one day provide a way to detect violent astrophysical events such as black hole collapses and supernova explosions. Gigantic clouds of dust and gas, along with other particles in space, absorb most of the radiation coming from these cataclysmic events, rendering them invisible to conventional telescopes. But neutrinos make it through unscathed.

Catching neutrinos can be tricky. To do it, the AMANDA team is converting a chunk of the polar plateau into the world's largest detector. The "telescope" will cover an area twice the size of a football field. The team uses hot water to drill holes into the ice cap that sink to nearly 12 times the height of the Washington Monument. Dangling from strings inserted in the holes will be a set of globes, or photomultipliers, that will capture flashes of blue light that occur when neutrinos collide with atomic nuclei in the ice.

So far, Lowder's team has installed eight strings with 152 optical modules at depths of 0.6 to 1.2 miles. By the end of 1998, 800 optical modules will be deployed. Even though the telescope is only one-fourth complete, it has already started to search for neutrinos. "We've shown that the technique works," says physicist Francis Halzen of the University of Wisconsin, one of the principal investigators. "This season we expect to see our first bona fide neutrino events, meaning we'll soon be able to do science for the first time."

Future Efforts

During the next five years, CARA astronomers will pursue their scientific goals by extending their observing programs with existing facilities and by building a second generation of telescopes. The degree to which they can expand depends partly on improvements in the infrastructure. Budget reviews will determine the degree of future growth.

"The philosophy that the U.S. Antarctic Program has adopted is that any science project which we support should be uniquely suited to Antarctica," says John Lynch, NSF program director for both CARA and AMANDA. "For astrophysics at the South Pole, this means exploiting the unique geophysical conditions that exist there to make important observations that cannot reasonably be done elsewhere on Earth."

Stark adds, "One hundred years from now, you may be able to do all of this from space. But right now this is the best place on Earth for us to develop these technologies and train our scientists." ☐

Beth Livermore is a New York-based science journalist. She has previously written for Popular Science, Smithsonian, *and* Natural History. *She went to Antarctica in 1996 as part of the NSF media visitors program.*

Bruce Koci/AMANDA

South Pole residents bathe in 105° F water. One AMANDA scientist says, "Even though the outside air is minus 30° F when you get out, you can drip dry if there is no wind. You are completely warm, standing there naked as you dry. When you are limited to two showers a week, this can be quite a luxury."

Opening a New Win

Gravitational waves may introduce strange new stellar animals.

George Krauter

low on the Universe

by James Trefil

Einstein's general theory of relativity remains our best explanation of the phenomenon of gravity, but it has accumulated a remarkably small number of experimental verifications. This is because Einstein's relativity differs significantly from the plain old garden-variety gravity of Isaac Newton in only a few unusual situations (the degree to which light bends as it comes around the sun, for example). This means that scientists are always on the lookout for new ways to test the theory.

One prediction of the theory that could, in principle, be tested in a laboratory on Earth has to do with something called gravitational waves. Whenever a mass moves, the theory states, a series of waves — small fluctuations in the force of gravity — will move outward from that mass, much as waves on a pond move away from the disturbance you create by throwing in a rock. The gravitational wave created when you wave your hand through the air is much too small to be measured, but events in which large masses move quickly, as happens in the collapse of a supernova, for example, would create waves that we should be able to detect.

Here's an example to help visualize this particular quest: Imagine a long, hollow, flexible plastic tube lying on the surface of a pond. If you threw a rock into the pond, that tube would undulate as the resulting waves passed by. By watching the tube, you could detect the presence of the waves *even if you couldn't see the water.*

In much the same way, changes in a tube would signal the passing of a gravitational wave. Instead of undulating, however, the tube would register the presence of a gravitational wave as changes in its cross-sectional shape. If you looked at the tube end on, you would see its circular cross section change to an ellipse with the long axis vertical, back to a circle again, then to an ellipse with its long axis horizontal, then back to a circle, and so on.

The first (unsuccessful) attempts to detect gravitational waves in the 1970s and 1980s used large metal bars in the role of our plastic tube. The bars were heavily instrumented to monitor changes in shape, but the experiments ultimately failed because the effects to be detected were so small. The expected deviation from a circular cross section of the cylinder, for example, was less than the distance across a single atom!

In experiments this sensitive, vibrations from the environment play a crucial role. Doors slamming, cars passing by outside, even the wind blowing against a building can start a metal bar vibrating, and these vibrations could easily masquerade as the effects of gravitational waves. To counter such "noise," scientists expend enormous effort to isolate their apparatus from the environment — typically, the apparatus is placed on a thick rubber shock absorber lying on a marble slab placed (if possible) on bedrock and not connected to the building in any way. Also, two experiments are run simultaneously in widely different locations, in the hope that noise at one location will not show up at the other.

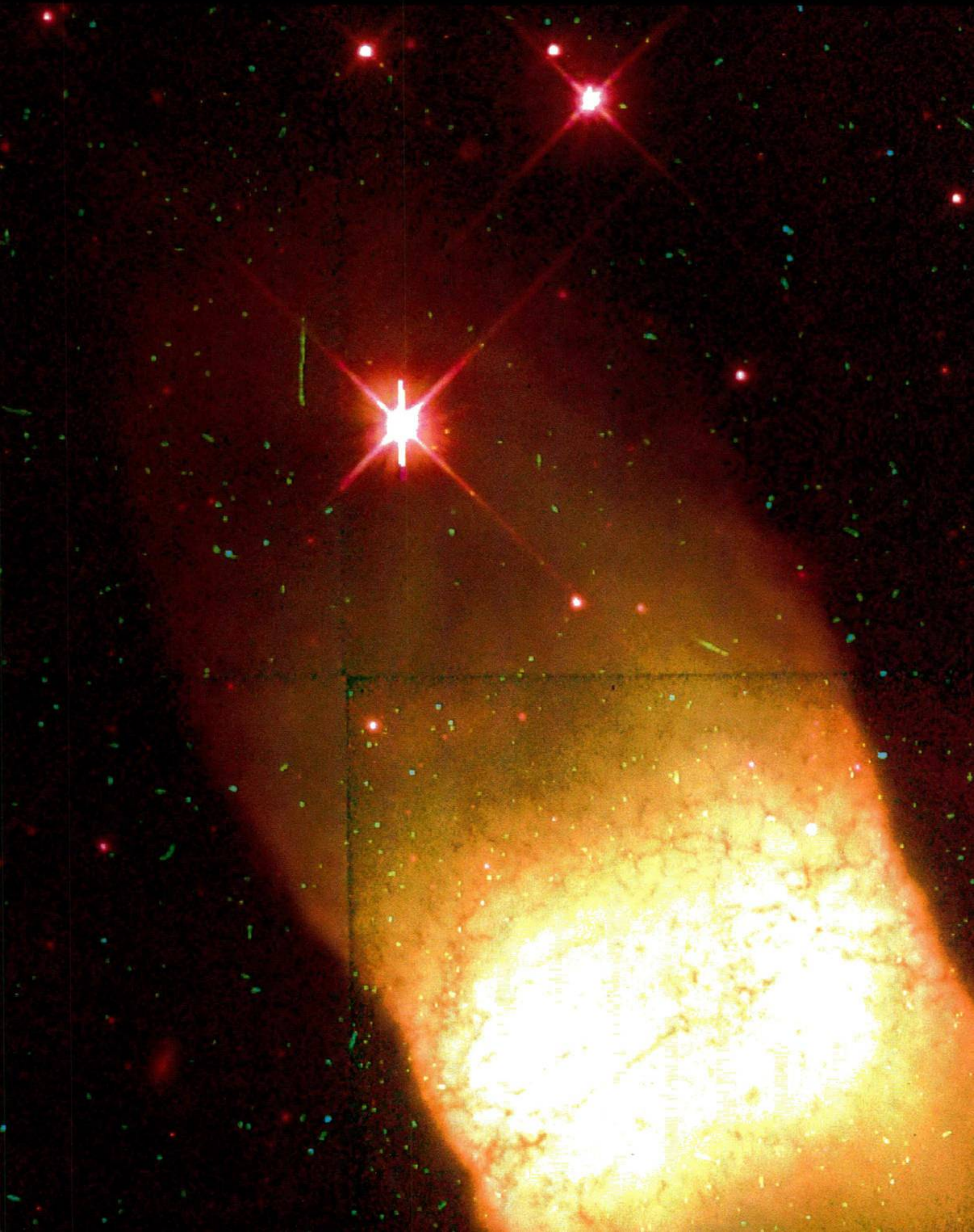
In 1994 ground was broken in Hanford, Washington, for the next generation of gravitational-wave experiments. The detection scheme in this $250 million project is more sophisticated than a simple metal cylinder. The working part of the detector is a pair of 2.5-mile-long metal pipes at right angles to each other. Inside each pipe is a high vacuum, and at the end of each, in a chamber isolated from vibrations, is a test mass. Think of these two test masses as isolated chunks of a metal "cylinder" 2.5 miles long and 2.5 miles in diameter. The changes in cross section described above will, in this apparatus, manifest themselves as small changes in the relative positions of the two masses with respect to each other.

When the system is working, a beam of light from a laser will pass through a partially silvered mirror so that half of the beam travels down each of the two arms. The two beams reflect off the test masses, come back down the pipe, and are re-combined. By detecting small shifts in the relative positions of the crests of the light waves, physicists will be able to monitor small changes in the positions of the test masses. A device like this is called an interferometer (because the two light beams "interfere" with each other on their return), and the entire project is called the Laser Interferometer Gravitational Observatory, or LIGO. Eventually, a second apparatus will be built in Louisiana to provide the protection against noise discussed above.

With these observatories, we will open an entirely new window on the universe. We will be able to "see" gravitational waves emitted not only by supernovae but by star systems in which the component stars revolve around each other, vibrating black holes, material falling into neutron stars and black holes, and an entire menagerie of strange stellar beasts. In the past, every time we've opened a new window on the universe — with satellite observatories, for example — we've found something wonderful. I expect LIGO to produce the same kind of excitement. □

From the book The Edge of the Unknown by James Trefil. Published by Houghton Mifflin Company, Boston. Copyright © 1996 by James Trefil. Reprinted by permission. James Trefil is a member of ASTRONOMY's new Editorial Advisory Board.

The death of an ordinary star creates an



extraordinary vision of light and beauty.

Inside a Star's Cocoon

by Karen Southwell

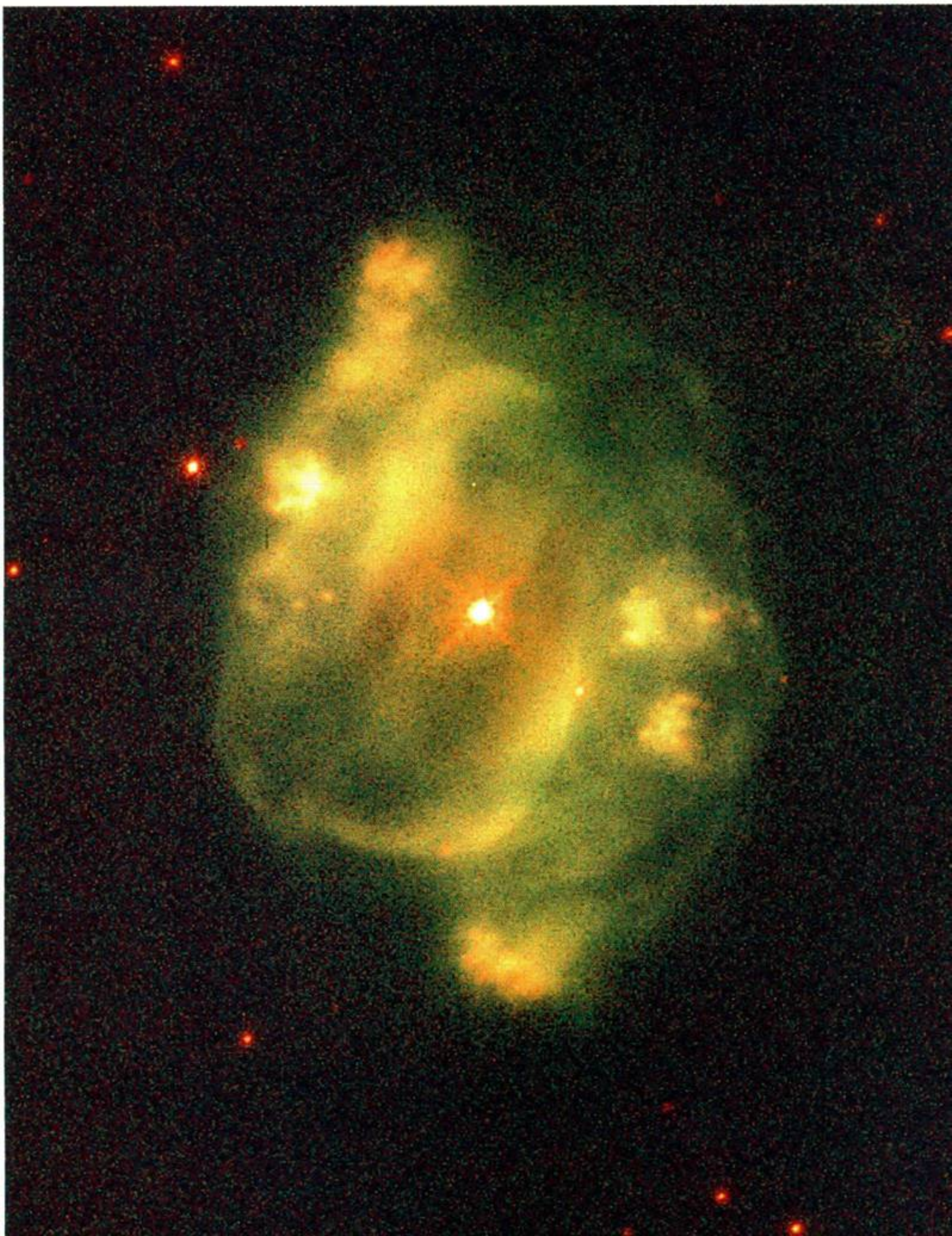
Astronomy provides stunning, almost magical pictures of the vast universe around us. In the past few years, we've been treated to a gallery of spectacular images, courtesy of the Hubble Space Telescope. What's more, the bonding of art and science was never more clearly demonstrated than in the group of objects known as planetary nebulae.

Indeed, you may feast your eyes upon some of HST's masterpieces in the following pages. But as you do so, give a thought to the creative forces behind them. What could have generated such delicate structures, such pleasing shapes and forms? Welcome to a side of physics that might just surprise you.

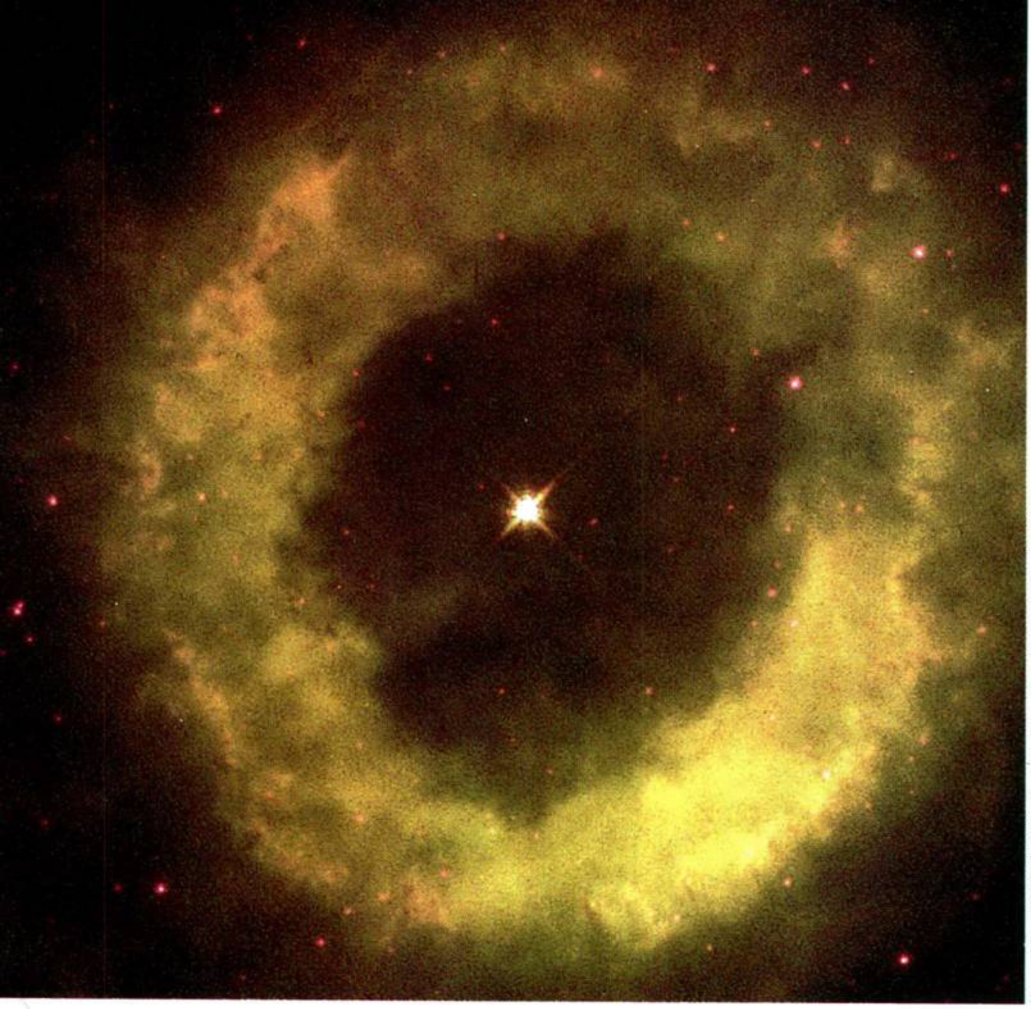
Like us, stars change as they mature, and eventually they die. Close to home, we have a star in a very stable phase of its life, burning hydrogen in its core — our own sun. However, given that the sun will do this for billions of years, don't expect to watch it evolve.

LEFT: The cloud forming planetary nebula IC 4406 in Lupus shows how a dense "belt" of dust around the star's equator forced outflowing material into bipolar lobes, one of which spreads toward bright red foreground stars.
RIGHT: The point-symmetric nebula NGC 5307 in Centaurus shows such precision in form that it was probably created by a wobbling, two-sided jet of material coming off the dying star.

Howard Bond (STScI), Robin Ciardullo (Penn State University), and NASA



Howard Bond (STScI), Robin Ciardullo (Penn State University), and NASA



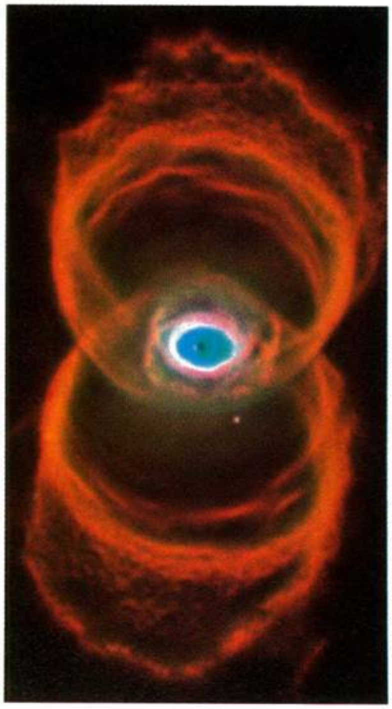
Howard Bond (STScI), Robin Ciardullo (Penn State University), and NASA

The mottled ring comprising NGC 6369 in Ophiuchus is an illusion: the nebula is a sphere, not merely a ring. The ring arises from seeing the densest part of the sphere, which surrounds the gleaming central star.

Looking farther afield, things become more interesting. In this galaxy, we see stars at various stages of maturity. This is because they were not all born at the same time, and some "grow up" faster than others, depending on how heavy they are. So, while we see many stars like the sun, many stars are reaching the end of their lives. "What's more, they enjoy one last and very dramatic final fling," says Bruce Balick, an astronomer at the University of Washington.

A Star's Life

For most of its life, a star generates its own heat and light through nuclear reactions occurring deep within its interior. Eventually, though, the fuel starts to run out. Rather than burning its central hydrogen reserve, the star begins to burn hydrogen in a shell around the dense helium core. This causes the star's core to contract but the outer layers to puff up and cool due to changes in the star's central region. The outer layers puff up to many times the size of the sun and cool down, which pushes the star toward the red (cool) end of the spectrum. Because of this, a star in this stage of its lifetime is known as a red giant. It is not yet ready to die, however, because although the hydrogen fuel supply is exhausted, the giant can survive by burning more complex elements in its core.



Raghvendra Sahai and John Trauger (JPL), and NASA

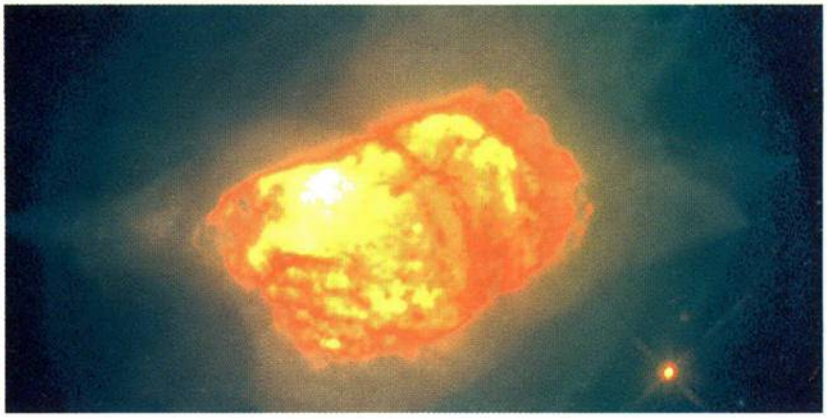
The Hourglass Nebula (MyCn 18) demonstrates axisymmetry.

Ultimately, though, a star cannot avoid its impending fate. The extra fuel supply does not last forever, and the giant's outer layers start to disintegrate. Great swaths of gas and dust are ejected from its surface and carried out into space on a global stellar breeze. This material forms the complex structures known as planetary nebulae, the cast-off shrouds of dying stars. These shrouds would be invisible, however, were it not for good illumination. Fortunately for us, nature has provided her own cosmic lamp to light up a planetary nebula. As the outer layers of the giant erode, the core of the star, which is extremely hot, becomes exposed. This heat acts as an amazingly bright natural light-bulb, casting ultraviolet radiation over the ejected shells and causing them to glow like a fluorescent bulb.

Because planetary nebulae shine in this way, their existence has been known for a long time — people were able to see them with the first telescopes. However, 18th-century observers couldn't see details in the structures — indeed, in the eyepiece these curious objects were thought to resemble planets. For this, early astronomers misnamed them planetary nebulae — a name that persists today — even though we now know planetaries have nothing to do with planets. More than 100 planetary nebulae can be seen through a typical backyard scope.

Taking a Closer Look

Recent views of planetaries with larger scopes, particularly with HST, have astonished astronomers. "When we saw the image of NGC 7027," says Howard Bond of the Space Tele-



H. Bond (STScI), R. Ciardullo (Penn State U.), and NASA

This image shows the axisymmetric planetary nebula NGC 7027 in Cygnus.

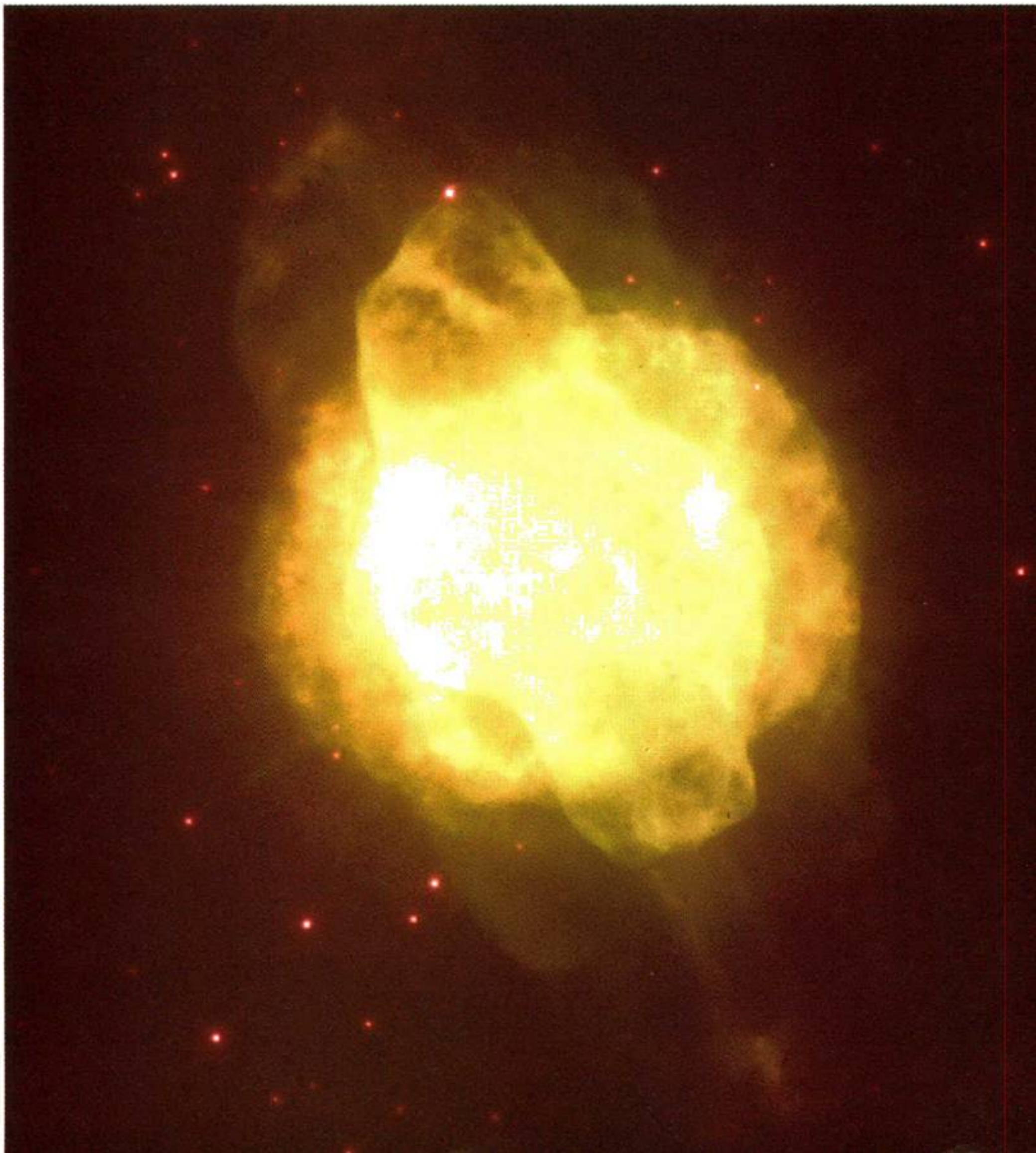
scope Science Institute, "we were amazed at how much more detail, especially in the dust structure, we were able to see with the increased resolution."

Suddenly, astronomers had unmasked a wealth of complexity in planetary nebulae — and they were confronted with an enormous challenge. How to explain these intricate structures, strange symmetries, and complex forms? Clearly, the way giants actually eject their surface layers could not be quite so simple as was once thought.

To define more precisely what sort of structures we're talking about, take a look at two planetary nebulae shown here — MyCn 18 and NGC 7027. They share a feature called axisymmetry. Like a butterfly, their shapes can be reproduced by reflecting one half across an imaginary line running through the center. "So what!" you may be thinking. Well, consider the basic shape of a star, which is simply a giant ball. When the star sheds its outer layers, you might expect they would be spherical. But instead, the planetary nebula becomes elongated rather than maintaining a rounded form.

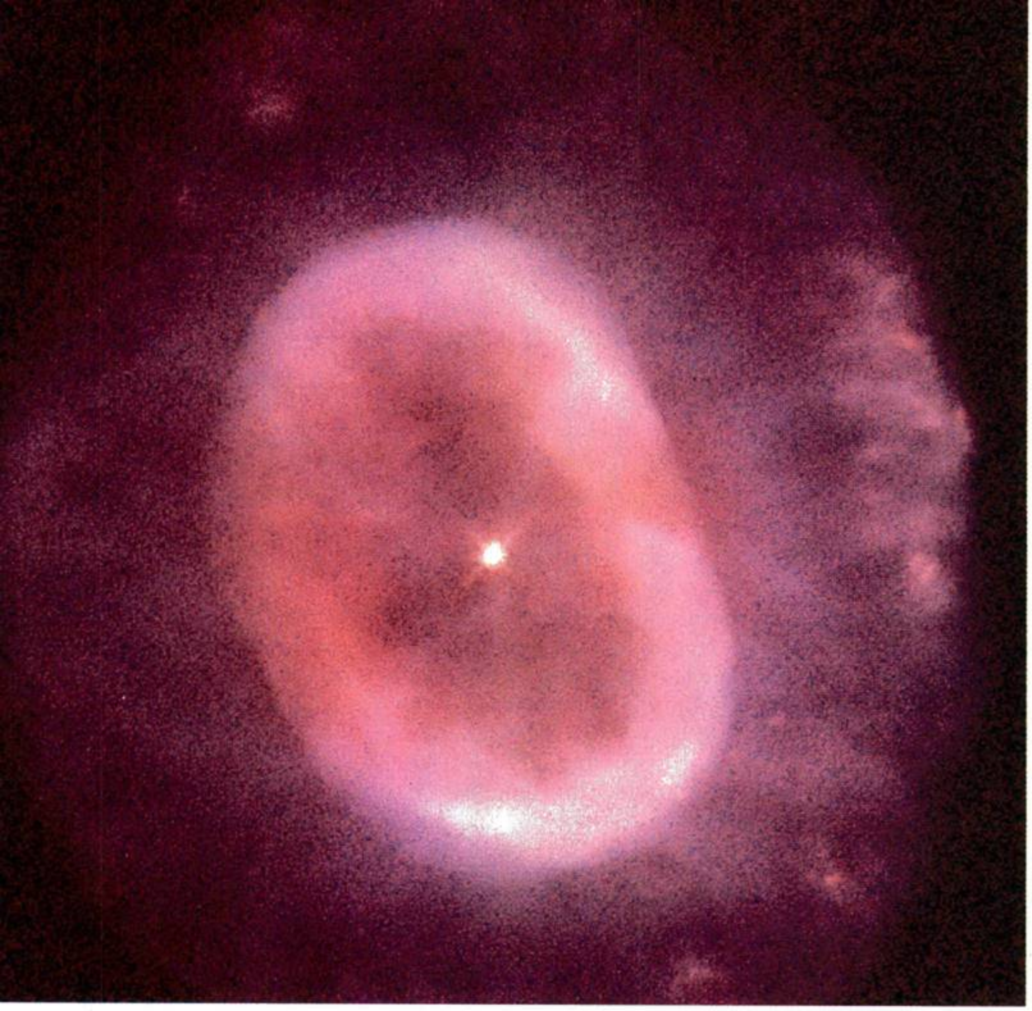
Opinion divides over the most probable cause of the axisymmetry. However, two clear camps exist. The first of these involves shaping by magnetic fields. As the dying star ejects its outer layers, the flow of material can be influenced by the field lines — the way iron filings group near a magnet. Importantly, the magnetic field has two separate components: one ring-like, which encircles the nebula, and one axial, which is directed along the length of the nebula. As the ejected material travels farther from the star, the ring-like field dominates the axial one. Thus, rather like a corset, the stronger circular field holds back material around the "waist" of the nebula, forcing it out along the vertical axis instead. Perhaps this is the way some planetary nebulae attain their hourglass figures. Can the corset be made strong enough to sustain that figure? If the star ejects material forcefully enough, the laces will surely break.

Astronomers are thus led to consider an alternative theory for the axisymmetry. Suppose that the dying star emits material from all over its surface, but that the outflow is denser at the equator. The material moves out into space in the form of a slow, global wind, with a slightly thickened "belt." But later, as the hot core of the giant becomes exposed, a much faster, spherically symmetric wind starts to blow. This catches up



Howard Bond (STScI), Robin Ciardullo (Penn State University), and NASA

The curious, axially symmetric nebula NGC 3918 in Centaurus shows how a star's fast wind penetrated more easily along the nebula's long axis, generating two enormous bubbles.



The white dwarf star buried deep inside Andromeda's NGC 7662 floats inside a tomb of nebular shells created by an old, slow wind (outer bubble) and a faster, young wind (inner, brighter ellipse). Such interplay creates fascinating shapes.

Howard Bond (STScI), Robin Ciardullo (Penn State University), and NASA

with the slow shell emitted earlier, ramming into it. Common sense suggests the outcome. The fast wind that flows from the equator will rapidly decelerate as it encounters the dense belt of the earlier shell. But the material streaming out lengthwise along the nebula finds much less resistance and travels farther. The result is a bipolar shape. Depending on the density contrast between the equatorial belt and the poles, an elliptical shell or an hourglass may form.

"It's amazing how many different axisymmetric shapes can be produced from this simple idea," says Adam Frank of the University of Rochester, who has performed many computer simulations of how planetary nebulae form.

Two's Company

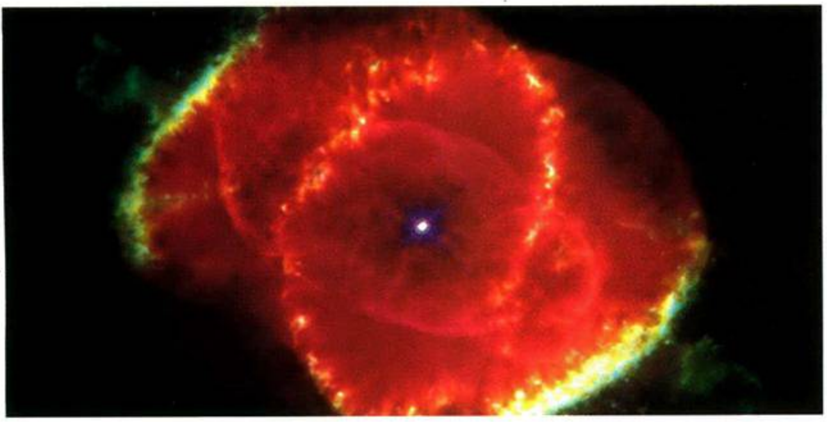
What causes the initial enhancement of density at the star's equator? A likely explanation is that the giant is spinning rapidly, causing the stellar wind to concentrate toward the equator. A similar sort of thing happens to Earth. Because it rotates, Earth's globe becomes slightly squashed so that the radius at the equator is slightly larger than the radius at the poles. This happens because a quantity known as angular momentum must be conserved.

What makes the giant spin so rapidly? This is a controversial point but, as Mario Livio of the Space Telescope Science Institute points out, "One excellent way of achieving this is if the star has a partner." When two stars get close enough, they influence each other through their mutual gravitational attraction. As the dying star evolved, its binary partner could have spiraled in toward it, causing the rotation speed to increase. It's another example of the conservation of angular momentum at work.

"The possibility of a stellar partnership at the heart of some planetary nebulae, rather than an isolated dying star, offers more than one bonus," adds Livio. For one thing, it would help the magnetic fields model, by reducing the required strength of the corset. What's more, take another look at MyCn 18, the Hourglass Nebula. The central star, or pair of stars, appears as the white dot (if there are two stars present, they are too close to be resolved in this image). This nucleus appears to lie at the center of the very large, orange hourglass. However, we see a smaller axisymmetric orange structure around the hot blue central region, which is clearly offset. It's hard to envisage how such an arrangement came about, particularly from a single star. But it does seem intuitively easier to achieve, if we allow for the effects of a complex gravitational dance between two interacting stars.

So are two stars better than one? This certainly seems to be the case for some planetary nebulae. Perhaps, though, the most compelling evidence lies within the curious objects called point symmetric nebulae. The planetary nebula NGC 6543 in Draco is also known by a far more descriptive common name, the Cat's Eye Nebula. Looking at the intricate structures of this most detailed object, it is not hard to see why. The Cat's Eye Nebula demonstrates a different kind of symmetry. Imagine rotating the nebula about its bright central nucleus. After one half-turn, you would produce something that closely resembles the original picture. This is known as point symmetry and has been seen in around 5% of extended planetary nebulae.

Exactly how does a stellar binary system help us in explaining this complicated structure? The vital clue lies in the fact that we see evidence for highly beamed outflows, or jets, in this object. Indeed, it is the jets that are the key to forming the structure. But they almost certainly can't be produced from a single star. In astronomy, when we see jets, an accretion disk is almost always there. Such disks occur when material spirals onto an object



Patrick Harrington (University of Maryland), Kazimierz Borkowski (University of North Carolina), and NASA

The Cat's Eye Nebula (NGC 6543) in Draco differs from the many other planetary nebulae in that it displays precise point symmetry.

under the force of gravity — the jets then shoot outward at right angles from the central regions of the disk, forming a sort of release mechanism for the highly energetic accretion process. In a planetary nebula's nucleus, the dying star may exert sufficient force to break up its small stellar partner, transforming at least some of it into a flattened disk.

In such a situation, the two oppositely directed jets thus triggered will travel outward, plowing into the stationary material of the nebula and compressing it. This causes heating, resulting in two glowing impact zones. Looking at the HST image of the Cat's Eye Nebula, this is exactly what we see. The green arcs of hot gas are clearly visible on opposite edges of the nebula.

Such twin jets, streaming from the center of the nebula and ejecting material in spurts, can naturally explain the point symmetry. To envision this, imagine a garden sprinkler with a double-sided nozzle. Each side of the lawn receives the same treatment — however, the water does not simply fall in two opposite patches, because the nozzle rotates. Similarly, in the Cat's Eye Nebula, we do not merely see two green hot spots, but rather extended arcs, implying that the jets are moving.

Wobbly Disks and Jets

At first sight, you might have thought that moving jets shouldn't be so hard to explain. After all, the disk from which they originate is spinning. However, the jets are at right angles to the plane of the disk, so that even as this rotates, the direction of the jets remains fixed.

Clearly, the disk must wobble — acting something like a spinning top. Because the toy tilts as it rotates, its spin axis traces out a pattern on the floor. So, imagine the jets in place of the toy's axis and you obtain a successful mechanism for producing extended point symmetry.

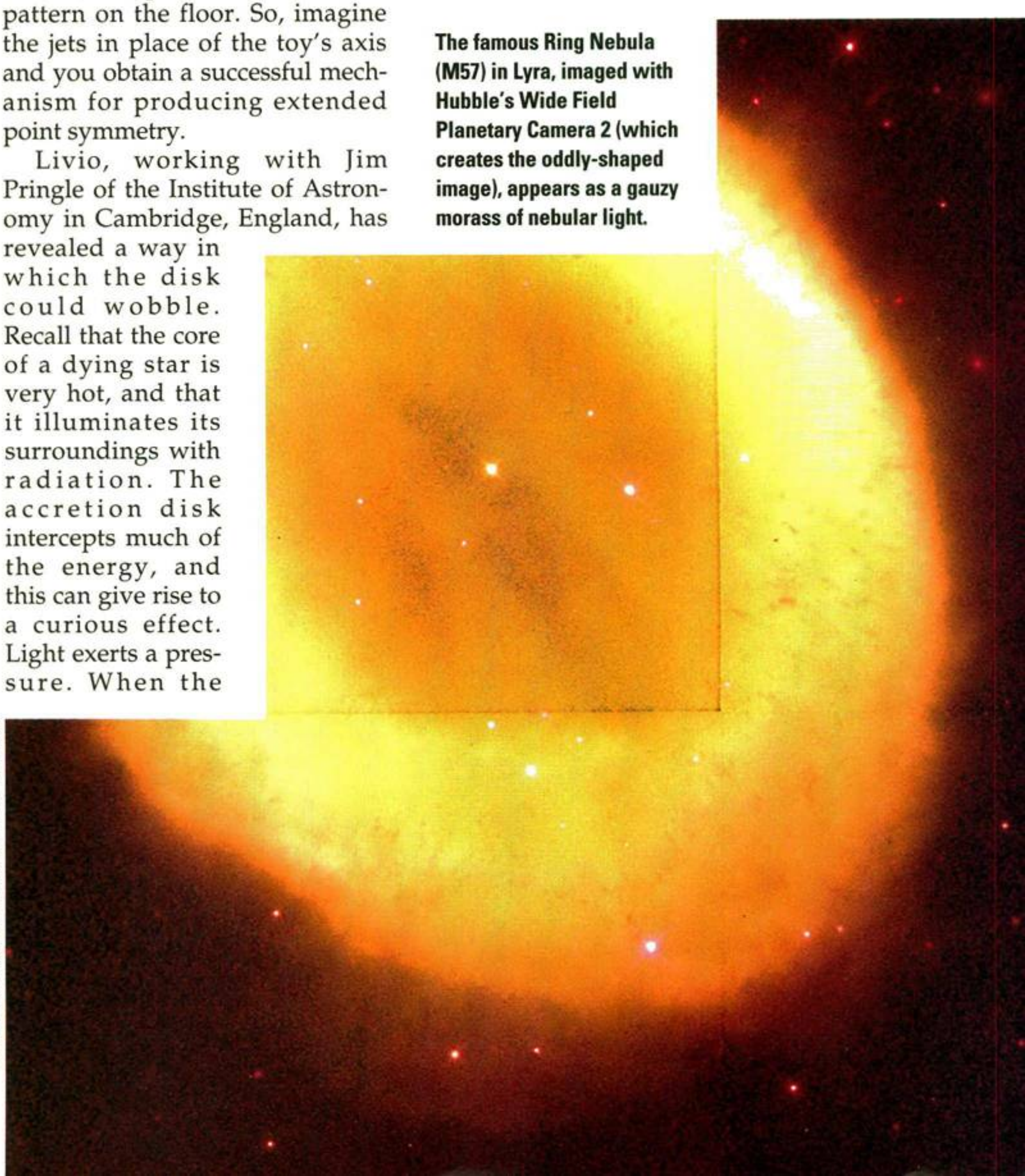
Livio, working with Jim Pringle of the Institute of Astronomy in Cambridge, England, has revealed a way in which the disk could wobble. Recall that the core of a dying star is very hot, and that it illuminates its surroundings with radiation. The accretion disk intercepts much of the energy, and this can give rise to a curious effect. Light exerts a pressure. When the light from the hot star bounces off the disk, the pressure of the radiation can cause the disk to bend. And when a warped disk spins, it tends to wobble — and so do the jets that emanate from its center.

Astronomers have come a long way in perceiving and understanding planetary nebulae. Yet mysteries remain. As improved generations of instruments show us progressively deeper levels of detail, the future looks promising. With any luck, we can anticipate many exciting new additions to our remarkable museum of sculptures in the sky. □

Karen Southwell is an astrophysicist at Oxford University.

All images in this article were made using the Hubble Space Telescope; several are previously unpublished.

The famous Ring Nebula (M57) in Lyra, imaged with Hubble's Wide Field Planetary Camera 2 (which creates the oddly-shaped image), appears as a gauzy morass of nebular light.



H. Bond (STScI), R. Ciardullo (Penn State U.), NASA

SKY ALMANAC

Spring meteors send off Hale-Bopp and its winter companions as evening's Venus and predawn Saturn gain against the sun's glare.

by Martin Ratcliffe

During May the night sky is poised to hand off spring, and even a lingering trace of winter, to the glorious skies of summer. The bright orange glow of Orion's Betelgeuse (yes, it can be pronounced "beetle-juice") lies low in the west on these May evenings. Its winter compatriot, Aldebaran, lingers deeper in twilight to the north. Looking south of Betelgeuse brings you to Orion's Belt, whose days are also numbered. By the end of May, all these sights succumb to the sun's overpowering glow.

As we say good-bye to the winter stars, **Venus** clambers steadily out of the sun's glare. Eventually it will climb higher in evening twilight and hang above the western horizon into 1998. For now though, the brilliant planet hugs the trees, making it a difficult object to spot. Visibility begins to improve in the latter part of May, but only slightly. By the 31st, Venus lies a scant 7° above the west-northwestern horizon 30 minutes after the sun sets.

The month's real drama, however, begins the month a bit higher up. We are about to bid farewell to **Comet Hale-Bopp** as it dives down through the ecliptic plane. Early in May, the comet lies in Taurus, a little less than 15° above the west-northwestern horizon as twilight fades away.

A fine photographic opportunity presents itself on the evening of May 8, when a slim crescent moon positions itself about 5° south of the comet. A camera loaded with ISO 400 film and fitted with a standard lens is all you need to capture the scene.

Set the camera on a sturdy tripod and thread in a bulb or cable release. With the lens set at its lowest f-stop number and focused on infinity, shoot a variety of exposures between 3 and 10 seconds. Don't forget to frame the conjunction with trees or nearby landmarks.

If Hale-Bopp's brightness holds close to the predicted 2nd magnitude, the comet should be an easy naked-eye object for much of the month. Pick it off as a fuzzy blob of light far to the right of Betelgeuse. If the comet fades to magnitude 3 or dimmer, you'll need binoculars to see it.

Highlights
by Alister Ling

Date	Event
4	Saturn's Dip behind the Moon ....(p. 72)
5	**First Views:** Meteors Sprinkle May Skies ....(p. 71)
8	Farewell to Hale-Bopp ...(p. 71)
25	**Observer's Challenge:** Pluto's Loyal Opposition ...(p. 74)

all month:

- The Ghost of Jupiter ....(p. 73)
- Mars Lingers at Sunset.......(p. 75)
- First Glimpse at an Evening Star ...(p. 75)

By May 20, the sinking comet slips below the horizon about an hour after the sun. Follow it for as long as you can — this will be humanity's last chance to catch a glimpse of this visitor until the year 5400.

Once the comet sets, **Mars** commands our attention from high in the south. It remains on view all evening, setting well after midnight. Although it still shines brightly at magnitude –0.1, it fades by 40 percent during May.

Earth continues to leave Mars behind as it travels in a faster orbit closer to the sun. The Red Planet's easterly motion through southeastern Leo picks up

Alan Dyer

After midnight the summer constellations greet you in the southeast. Look for Scorpius's bright red star Antares, whose name comes from a Greek word meaning "rival of Mars." How does the color and brightness of Mars measure up to Antares?

1997
MAY

1 Neptune is stationary, 7 p.m. EDT

3 The moon is at perigee (227,811 miles from Earth), 7:16 a.m. EDT

4 The moon passes 0.8° north of Saturn, noon EDT (page 72)
Eta Aquarid meteor shower peaks (page 71)

5 The moon passes 1.2° south of Mercury, noon EDT

6 New moon is at 4:46 p.m. EDT

8 The moon passes 0.6° north of Aldebaran, 10 a.m. EDT

13 Uranus is stationary, 5 a.m. EDT

14 First quarter moon is at 6:55 a.m. EDT

15 The moon is at apogee (251,165 miles from Earth), 6:11 a.m. EDT

16 The moon passes 2° south of Mars, noon EDT

19 Venus passes 6° north of Aldebaran, 4 a.m. EDT

22 Full moon is at 5:13 a.m. EDT
Mercury is at greatest western elongation (25°), 7 p.m. EDT

25 Pluto is at opposition, 6 a.m. EDT (page 74)

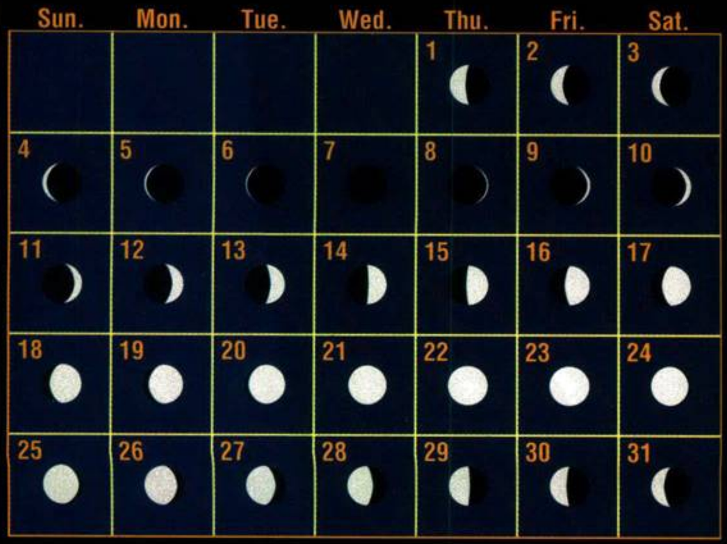
26 The moon passes 4° north of Neptune, noon EDT

27 The moon passes 4° north of Uranus, 4 a.m. EDT

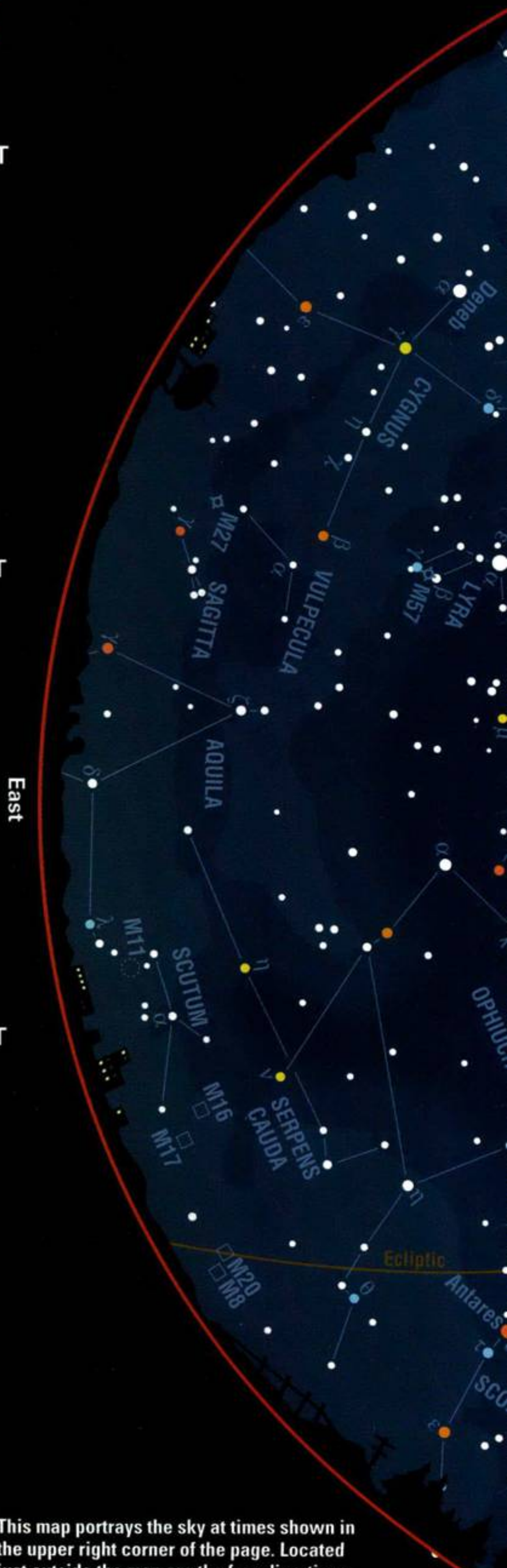
28 The moon passes 4° north of Jupiter, 2 a.m. EDT

29 The moon is at perigee (229,776 miles from Earth), 2:58 a.m. EDT
Last quarter moon is at 3:51 a.m. EDT

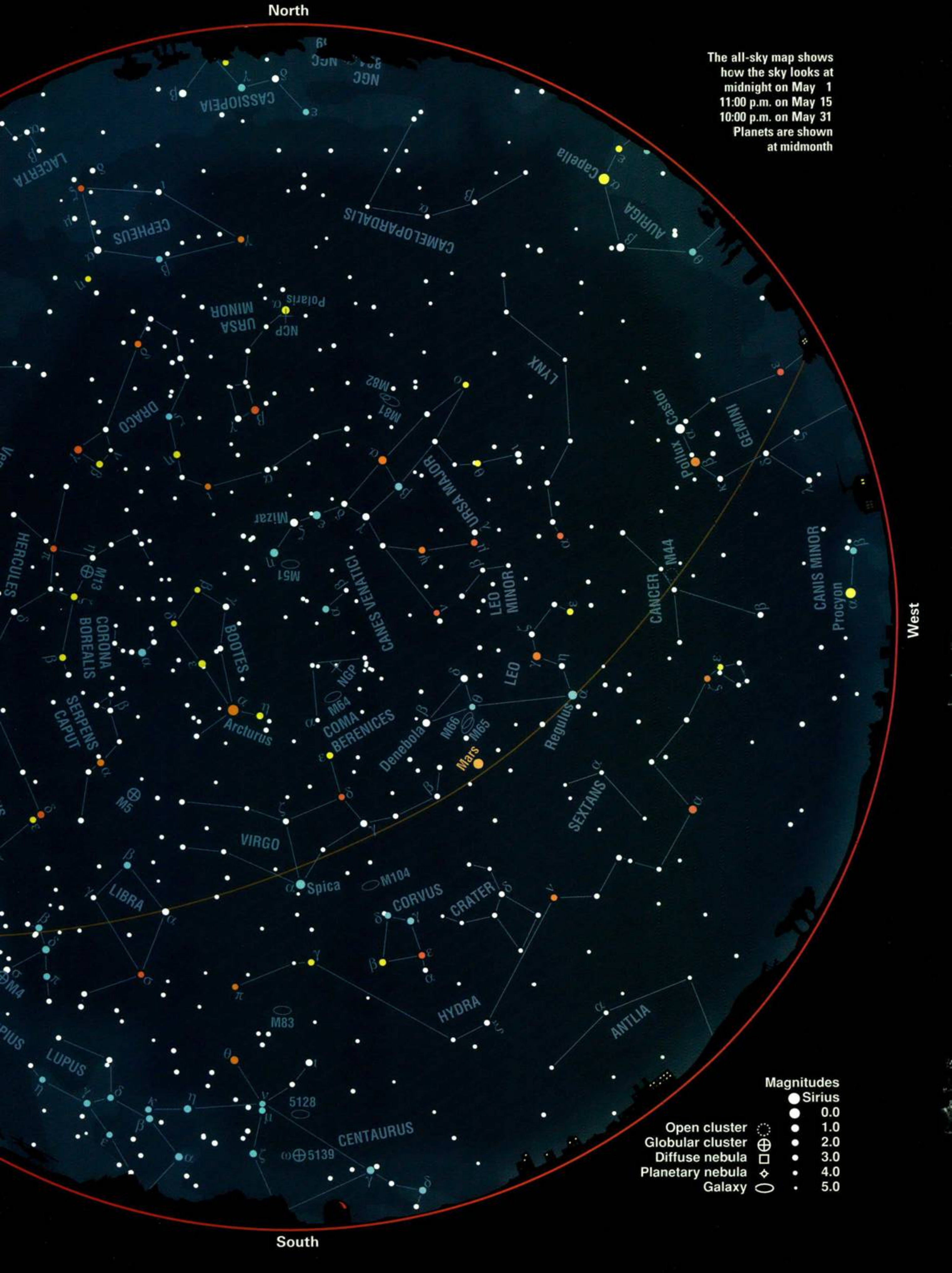
31 The moon passes 0.5° north of Saturn, 11 p.m. EDT



Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31



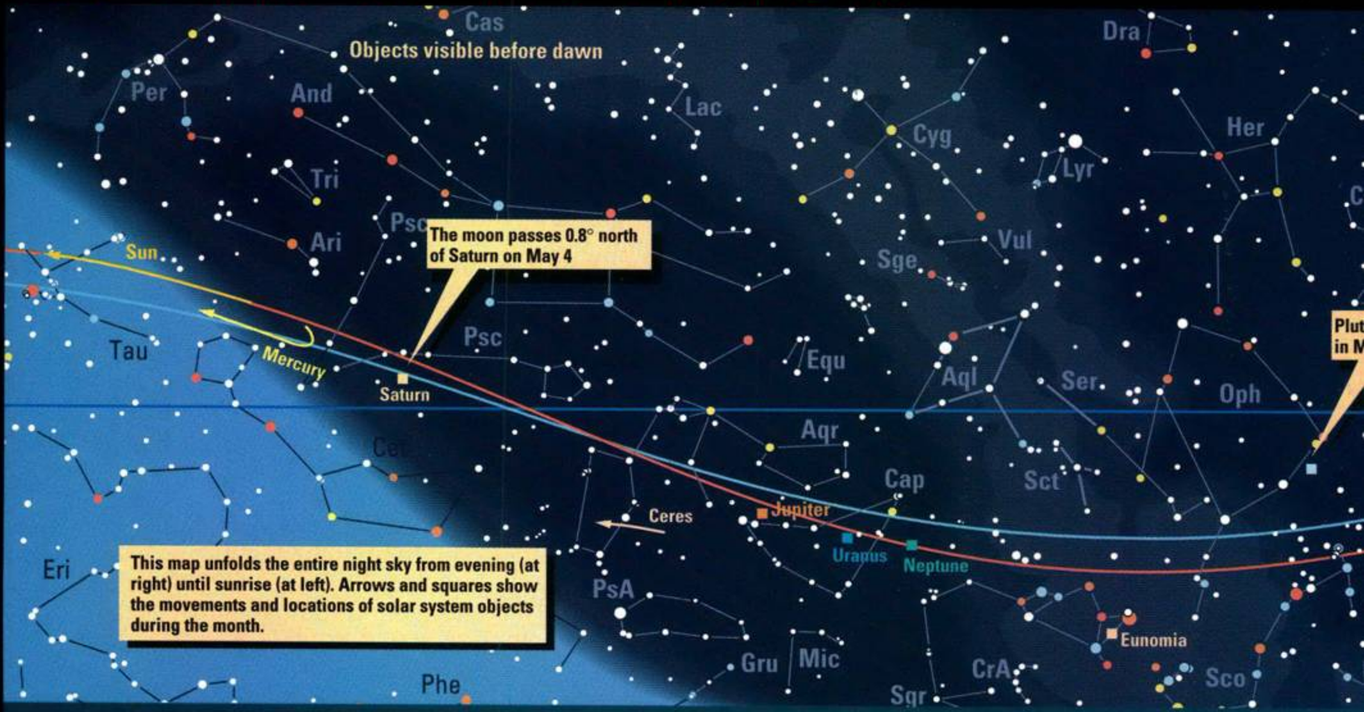
This map portrays the sky at times shown in the upper right corner of the page. Located just outside the map are the four directions: north, south, east, and west. To find stars above your horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.



The all-sky map shows
how the sky looks at
midnight on May 1
11:00 p.m. on May 15
10:00 p.m. on May 31
Planets are shown
at midmonth

North
South
West
CASSIOPEIA
LACERTA
CEPHEUS
CAMELOPARDALIS
Capella
AURIGA
URSA MINOR
Polaris
NCP
DRACO
LYNX
M81
M82
URSA MAJOR
Mizar
M51
Castor
Pollux
GEMINI
HERCULES
M13
CORONA BOREALIS
BOOTES
CANES VENATICI
LEO MINOR
CANCER
M44
CANIS MINOR
Procyon
NGP
M64
COMA BERENICES
Arcturus
SERPENS CAPUT
Denebola
M66
M65
LEO
Regulus
Mars
SEXTANS
M5
VIRGO
Spica
M104
LIBRA
CORVUS
CRATER
M4
HYDRA
ANTLIA
M83
LUPUS
5128
CENTAURUS
ω 5139
Magnitudes
Sirius
0.0
1.0
2.0
3.0
4.0
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

THE PATH OF THE PLANETS


Cas
Objects visible before dawn
Per
And
Lac
Dra
Cyg
Her
Tri
Lyr
Psc
Ari
Sun
Vul
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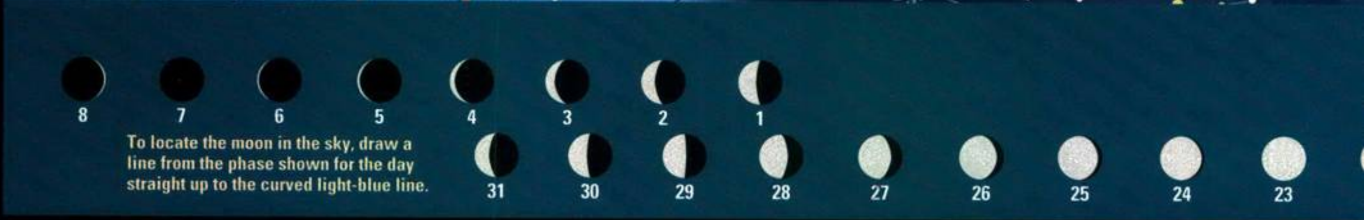
Tau
Mercury
Saturn
Psc
Equ
Aql
Ser
Oph
Aqr
Cet
Cap
Sct
Ceres
Jupiter
Uranus
Neptune
Eri
PsA
Eunomia
Gru
Mic
CrA
Sco
Phe
Sgr

The moon passes 0.8° north of Saturn on May 4

This map unfolds the entire night sky from evening (at right) until sunrise (at left). Arrows and squares show the movements and locations of solar system objects during the month.


8
7
6
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4
3
2
1
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29
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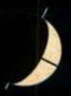
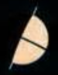
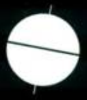
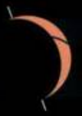
27
26
25
24
23

To locate the moon in the sky, draw a line from the phase shown for the day straight up to the curved light-blue line.

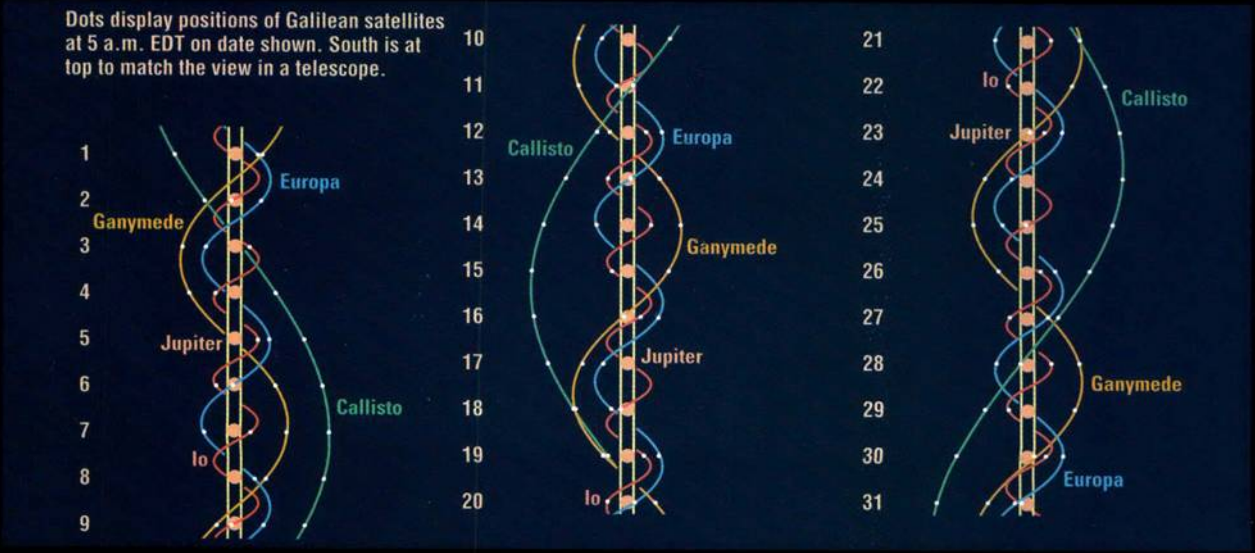
10"

S
W — E
N

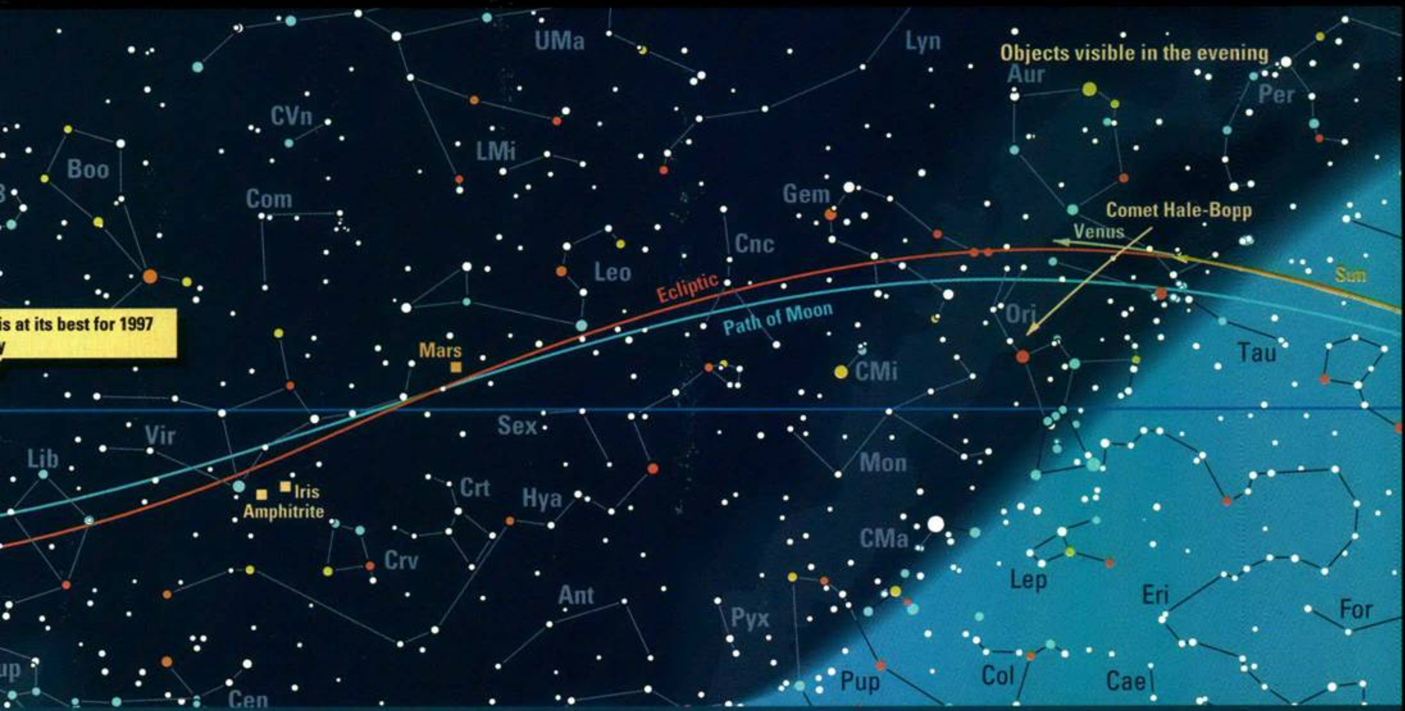
PLANETS	MERCURY	MERCURY	VENUS	MARS	MARS
Date	May 15	May 31	May 15	May 1	May 31
Magnitude	1.2	0.0	−3.9	−0.4	0.2
Angular Size	9.6"	7.0"	9.9"	11.5"	9.1"
Illumination	25%	54%	98%	93%	89%
Distance (AU) from Earth	0.697	0.962	1.686	0.813	1.026
Distance (AU) from Sun	0.463	0.409	0.720	1.625	1.596
Right Ascension (2000.0)	1h59.9m	2h58.1m	4h13.4m	11h14.7m	11h34.5m
Declination (2000.0)	8°52'	13°49'	21°17'	7°02'	3°46'

JUPITER'S MOONS

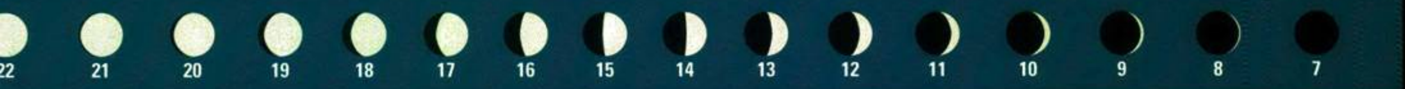


Dots display positions of Galilean satellites at 5 a.m. EDT on date shown. South is at top to match the view in a telescope.


UMa
Lyn
Aur
Per
CVn
LMi
Boo
Com
Gem
Comet Hale-Bopp
Venus
Cnc
Leo
Ecliptic
Sun
Path of Moon
Ori
Mars
CMi
Tau
Sex
Vir
Lib
Mon
Crt
Hya
Iris
Amphitrite
CMa
Crv
Lep
Eri
For
Ant
Pyx
up
Pup
Col
Cae
Cen

Objects visible in the evening

is at its best for 1997
y


22
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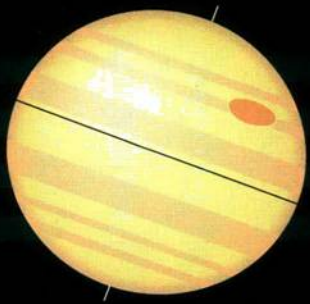
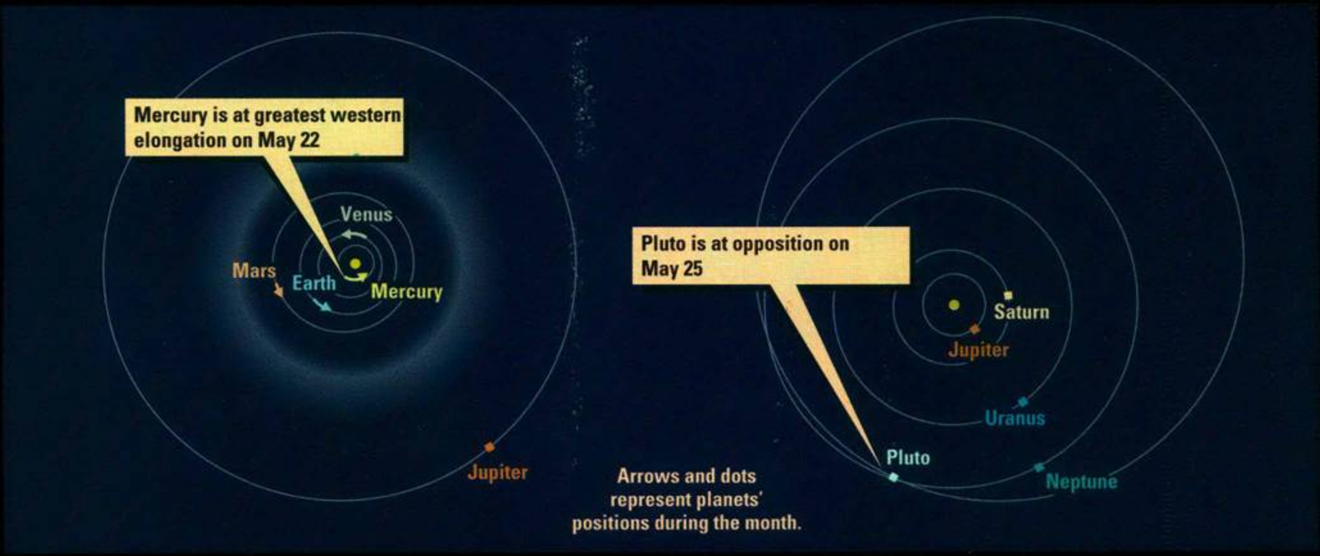


JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
May 15	May 15	May 15	May 15	May 15
–2.3	0.7	5.8	7.9	13.7
40.0"	16.3"	3.6"	2.3"	0.1"
99%	100%	100%	100%	100%
4.931	10.201	19.520	29.722	29.006
5.091	9.432	19.815	30.152	29.977
21h34.1m	1h01.2m	20h45.2m	20h08.1m	16h19.8m
–15°09'	4°06'	–18°41'	–19°45'	–8°18'

THE PLANETS IN THEIR ORBITS


Venus
Mars
Earth
Mercury
Jupiter
Saturn
Jupiter
Uranus
Pluto
Neptune

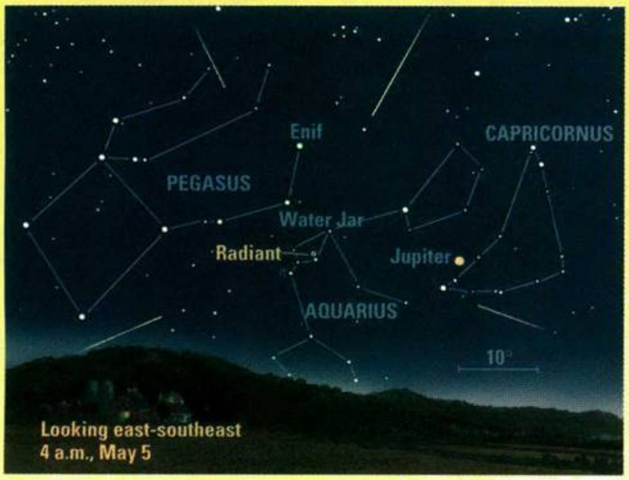
Mercury is at greatest western elongation on May 22

Pluto is at opposition on May 25

Arrows and dots represent planets' positions during the month.

First Views:

Meteors Sprinkle May Skies



Looking east-southeast
4 a.m., May 5

ASTRONOMY: Elisabeth Rowan

Rick Schmidt

One of spring's more notable meteor showers, the Eta Aquarids, pours forth from Aquarius during early May. Up to 20 meteors per hour will appear to come from the Water-bearer's Y-shaped water jar on the morning of May 5. Peak activity arrives on the evening of May 4, although dedicated observers will glean a steady trickle of Eta Aquarids between April 18 and May 28.

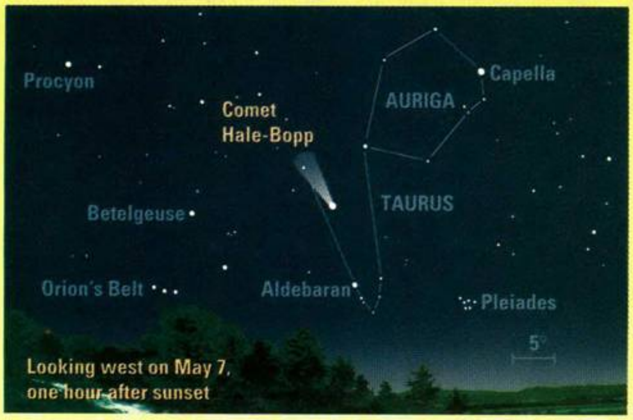
The best views come when the moon is out of the way, which this year occurs during the first two weeks of May. The feeble glow from a delicate waning crescent less than two days before new should not diminish the view on the morning of May 5.

Meteor showers occur when Earth plows into a stream of dust and sand particles left along a comet's trail. The Eta Aquarids are flotsam from none other than Halley's comet. Tiny grains of rock literally burn up as they dig into our atmosphere at 40 miles per second (65 km/s). This high speed makes Eta Aquarids famous for their bright fireballs and long paths.

An Eta Aquarid meteor can appear anywhere in the sky, but your best bet is to look overhead where the trails will be longer. Tracing the path of at least two Eta Aquarids will betray the shower's radiant in Aquarius, near the 4th-magnitude star Eta (η) Aquarii.

Watching a shower is the ultimate in observational relaxation. A deck chair, sleeping bag, hot drink in a thermos, and viewing companions are all you need to enjoy speedy "shooting stars." A dark sky is another requisite if you want to see the greatest number of meteors. — *Alister Ling*

Farewell to Hale-Bopp



Looking west on May 7,
one hour after sunset

ASTRONOMY: Terri Metzger

Early May finds Hale-Bopp a respectable 2nd-magnitude comet low in the west-northwest after sunset. Despite its brightness, finding the comet might be tougher than you think. The twilight sky is on the bright side, and your eyes will not be dark adapted. Not only that, the comet is slipping toward the horizon. Bit by bit, twilight eats away at the tail and coma of this magnificent fuzzy ball of light.

By the end of May's first week, Hale-Bopp crosses the ecliptic on a southward plunge. On the evening of May 8, a two-day-old crescent moon shares the same binocular field 5° south of Hale-Bopp. Ironically, while the moon may make the comet easier to find, moonlight might overwhelm Hale-Bopp's faint light. A photograph should record a lingering gossamer tail. Don't be afraid to try a variety of exposures and compositions. Film is pretty cheap. Bright comets are rare.

After midmonth, Hale-Bopp's visibility plummets as it sets nearer to the sun. When's the last time you'll see this comet with the naked eye or binoculars? — *A. L.*

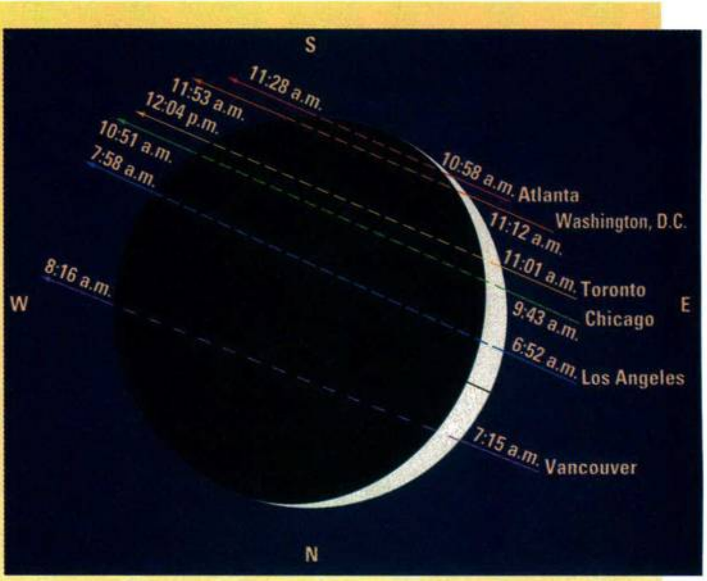
speed during May, but Mars can't outrun the moon. Look for the waxing gibbous moon as it passes south of the ocher-colored planet on May 16.

By May 27 Mars lies 1 AU, or 93 million miles, from Earth and presents an apparent diameter of less than 10". This small angular size makes seeing the planet's subtle surface features a challenge through backyard telescopes.

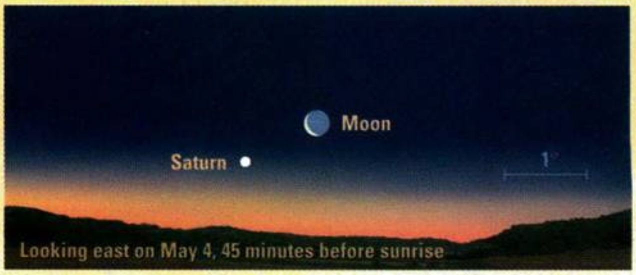
Once darkness falls, the spring sky begins showing off other subtle offerings. Leo is past the meridian high in the south, while the dim stars of Cancer the Crab seemingly lead the whole procession to the western horizon. Binoculars reveal in Cancer the coarse nature of what looks like a fuzzy patch of

Saturn's Dip behind the Moon

Lee Coombs



ASTRONOMY: Terri Metzger



Looking east on May 4, 45 minutes before sunrise

ASTRONOMY: Terri Metzger

Sunday, May 4, could be called Super Saturn Sunday. That's when North American observers have front row seats to a cover-up, or occultation, of the planet by our moon. Eclipse seasons for Saturn are rare (the last one ended in 1991), so take advantage of this year's when you can. The season plays out with at least one occultation of Saturn each month through the end of 1997. May's takes place during daylight, so you'll need a modest amount of preparation to witness it.

Start observing about 45 minutes before sunrise. Low in the eastern sky, flush with dawn colors, lies the delicate crescent moon with Saturn. Binoculars will highlight this beautiful conjunction. If you have a motorized equatorial telescope, align its mount, center your eyepiece's field of view on Saturn, and flip on the clock drive. Now your scope will follow the Ringed Planet throughout morning until occultation time.

The action really begins at midmorning — refer to the diagram for disappearance times at a location near you. For the best view, make sure your southern horizon is free of tall trees and buildings. If your scope can't track with the sky, start searching for the moon about half an hour before the occultation begins. Binoculars will help. Look about 30° — three fist widths held at arm's length — ahead of the sun in the sky.

Once you find the moon, slew slightly to the left to locate Saturn. It should stand out quite easily at low power. If the atmosphere is steady, apply a higher power for more dramatic views. A light yellow or orange filter should enhance contrast and cut some of the blue sky's brightness.

Saturn's daylight disappearance will be easy to see because our moon's eastern limb is lit up. Catching Saturn's reappearance some 30 to 60 minutes later might be harder. Consider dropping to a lower power while waiting for the planet to reemerge from behind the moon's unlit portion. Once reemergence begins, jump up to a higher magnification to witness Saturn's rings returning to view. — *A. L.*

light to the naked eye. It's the Beehive star cluster, also called Praesepe, and designated M44 on the Almanac's sky map.

Southeast of Mars shines Spica, a magnitude-1.0 resident of Virgo. Spica is an eclipsing binary, varying about 0.1 magnitude every four days. Host constellation Virgo is the second largest constellation in the sky, covering almost 1,300 square degrees.

Virgo is associated with many myths: a beautiful maiden, the Greek goddess of justice (Astraea), and the Greek goddess of the harvest (Demeter). Sometimes she is cast as Demeter's daughter, Persephone.

Such moniker mayhem almost seems appropriate for a constellation of Virgo's expanse. Her size in the sky is surpassed only by the labyrinthine constellation of Hydra the Water Snake. Hydra stretches about 100° from the dim stars of spring to the very fringes of summer's Milky Way. Look below M44 for the sea snake's head, a compact grouping of six 3rd- and 4th-magnitude stars. The brightest star in Hydra is 2nd-magnitude Alphard, the Solitary One, lying 20° south and a little west of Regulus. The balance of Hydra meanders south of Virgo until it butts against Libra and Centaurus.

Resting on Hydra's back to the south of Virgo are two quaint little constellations, Corvus the Crow and Crater the Cup. When the god Apollo ordered Corvus to bring him a cup of water, the crow dallied too long enjoying some figs by a river. To explain the delay, Corvus trumped up a wild tale of catching Hydra in his claws. An unimpressed Apollo cast the water snake, the pesky crow, and the cup into the sky.

High above these ancient constellations and practically overhead at midnight shines Bootes the Herdsman, with its brilliant ruby-colored luminary Arcturus. Arcturus is the 4th-brightest star in the entire sky, after Sirius, Canopus, and Alpha Centauri. East of Bootes lies Corona Borealis, while to the west is inconspicuous Coma Berenices.

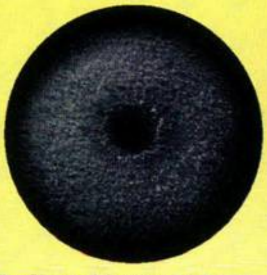
Galaxies blanket this region. One of the best is

The Ghost of Jupiter

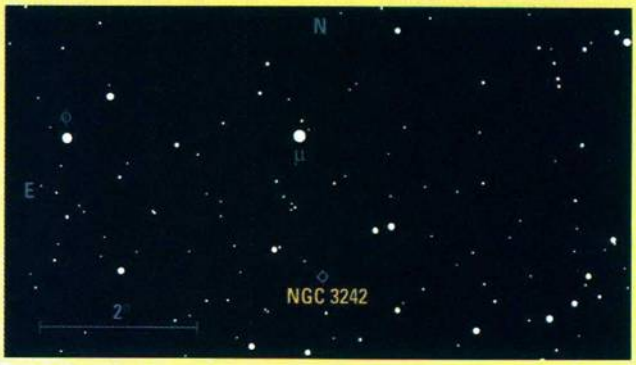
It was the 18th-century visual observer William Herschel who coined the term "planetary nebula." His telescope showed these small, round, nebulous disks as pale versions of the outer gas giant planets in our solar system.

But rather than thinking they were planets, Herschel mistakenly thought planetaries were collapsing clouds in the midst of creating new stars. We know today that these shells of gas are expelled by dying stars.

One of the sky's finest but most overlooked planetary nebulae is NGC 3242 in Hydra. The 19th-century English observer Admiral Smyth noticed a similarity in size and color to the planet Jupiter, only much paler. His label — the Ghost of Jupiter — persists to this day. The Ghost's 30" by 16" disk is brighter, about 8th magnitude, than its more famous cousin in Lyra, the Ring Nebula, though the Ghost is about half M57's size.


The Ghost of Jupiter, NGC 3242, 10-inch f/4.5 reflector, 136x by Dan Troiani

Ronald Royer



Astronomy: Terri Metzger

The biggest roadblock to finding NGC 3242 is its location in a very star-poor region of the sky. Start your search by dropping approximately 30° south of Regulus to reach a zigzag pattern of stars that make up the body of Hydra, the celestial Water Snake. Then pan about 2° south of 4th-magnitude Mu (μ) Hydrae to find NGC 3242's faint disk in a low-power field of view. The Ghost of Jupiter's epoch 2000 coordinates are 10h24.8m, –18°38'.

I find the Ghost readily visible through a 6-inch f/5 telescope at 50x. Crank the power up as high as atmospheric steadiness will allow to get a better look at the nebula's detail.

Like Jupiter, the Ghost is not perfectly round. Scopes over 10 inches reveal a second shell; anything 8 inches or larger shows a hint of color. Observers report everything from blue through yellow. Staring straight at the nebula will stimulate your color-sensitive cones to reveal any hue. What do you see?

While you're in this area of the sky, try looking for the blood red variable star U Hydrae, which shines at about 6th magnitude only 6° north-northeast of the Ghost of Jupiter. — *A. L.*

M64, a magnitude-8.5 spiral called the Blackeye Galaxy. In a 6-inch telescope, you can see the dark blob of dust (offset from the galaxy's nucleus) that gives M64 its name. Look for this celestial shiner 5° to the northwest of Alpha (α) Comae Berenices.

Looking north, the venerable Ursa Major begins a slow descent on its path around the celestial pole with its conspicuous asterism, the Big Dipper. The bear seems to be hauling Hercules the Strongman up into the eastern sky, where he replaces Bootes on the zenith by around 2 a.m.

While all this powerlifting is happening, don't forget to glance to the southeast where the stars of summer almost surreptitiously pop up over the horizon. First to rear its head is Scorpius the Scorpion, with yet another ruddy orb, Antares, to join Arcturus and Mars.

Planted between Scorpius and Hercules is the sprawling constellation of Ophiuchus the Serpent Bearer. On the Scorpius-Ophiuchus border, 2° west of magnitude-4.6 Upsilon (υ) Ophiuchi, we enter Pluto territory. **Pluto** reaches opposition on May 25, so it lies due south around midnight. It is not an easy object to see at magnitude 13.7. You'll need at least an 8-inch telescope and a detailed chart to find this milestone at the edge of the solar system. Plan on a few nights of careful observing to verify Pluto's motion against the background stars.

By the time Scorpius, Ophiuchus, and Hercules cross the meridian during the early morning hours, three more planets come into view: Jupiter, Uranus, and Neptune.

Jupiter clears the east-southeastern horizon during the first two hours after midnight. At magnitude –2.3, the brilliant planet makes an unmistakable addition to the dim stars of Capricornus. Shadowing Jupiter through Capricornus at a plodding pace is magnitude-5.8 **Uranus**. Pick up this distant wanderer in binoculars a little east of a point halfway between Beta (β) and Psi (ψ) Capricorni.

Farther out into the solar system, and consequently moving even more slowly, is magnitude-7.9 **Neptune**. It lies in far western Capricornus, to the west of Uranus. A 2.4-inch scope should be enough to resolve Neptune as a blue-gray dot a few degrees north of globular cluster M75.

By now the night sky is in full bloom with summer constellations. Aquila the Eagle is high in the south by 4 a.m., its outstretched wings represented by stars below magnitude-0.8

Observer's Challenge: **Pluto's Loyal Opposition**

It's a proud moment in any backyard observer's career when Pluto finally gets pegged. Sure, it's no brighter than the faintest star visible through a typical 8-inch scope, but the point is just to *see* our solar system's most remote planet.

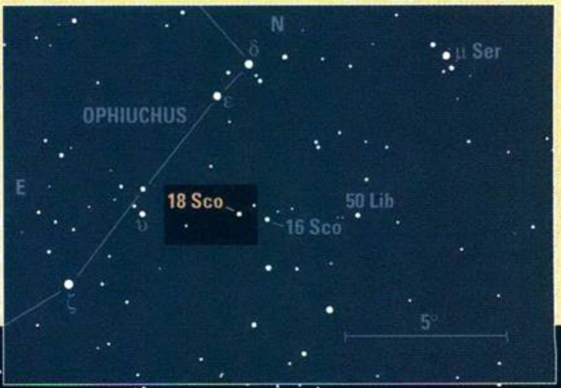
With Pluto reaching opposition on May 25, rising near sunset and reaching its highest point in the south around midnight, now's your chance to land this 1,400-mile-diameter world as an entry in your observing logbook.

To put Pluto in perspective, it's only ⅔ the size of our moon but two to three times more reflective. Their differences in distance are staggering. Pluto is 4 light-hours away, compared with the Moon's 1 light-second. This is what makes Pluto so faint (magnitude 13.7) and small (0.11 arcsecond across). In comparison, our moon shines at magnitude –13 and spans 1,800 arcseconds of sky.

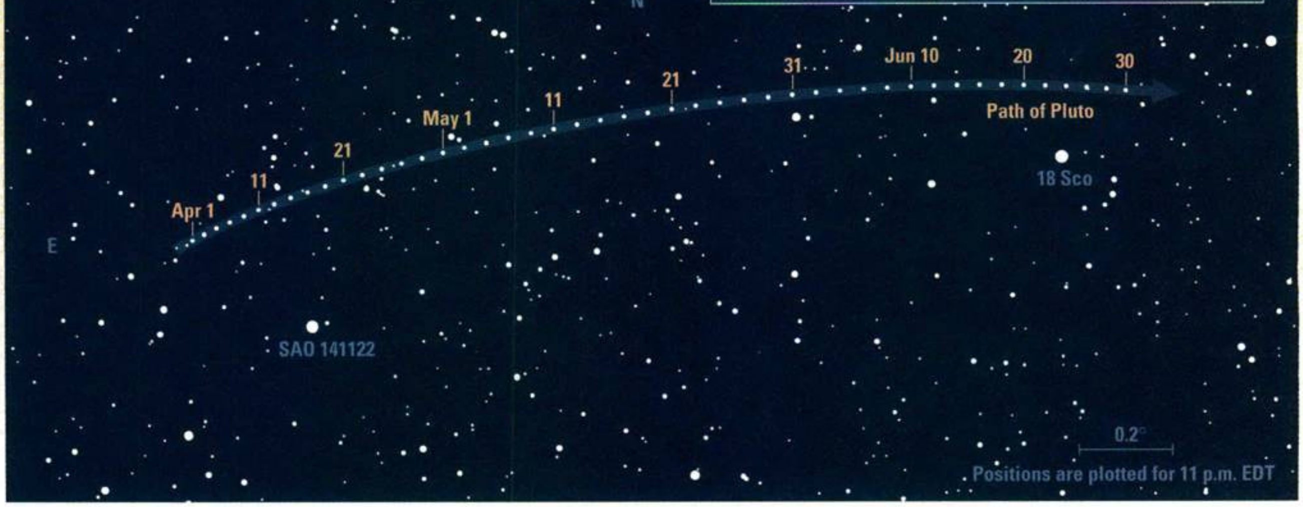
So bagging Pluto requires a patient search, guided by a detailed finder chart. First, orient yourself with binoculars by locating the stars 16 and 18 Scorpii. Then, with your scope, pan east from 16 to 18 to land in Pluto's field.

But which faint object is it? The best way to nail Pluto is to sketch a candidate field using the chart below. Consult the dates on the map to settle on which area of Pluto's path you should draw. Make your drawing. Then, a night or two later, return to the same spot to make another sketch, and then compare. The faint "star" that moves between evenings is Pluto.

Experienced observers advise that higher power, 180x to 300x, boosts the contrast between faint blips and the background sky. Another worthy tip is to wait until midnight, when Pluto is at its highest and your eyes have dark adapted. A Pluto search will take time, but identifying it is a rewarding experience. — *A. L.*



ASTRONOMY: Elisabeth Rowan



Altair, this constellation's brightest star.

"Altair" comes from the Arabic phrase, "al-nasr al-ta'ir," which means "flying eagle." The name seems all the more appropriate, since in reality Altair spins very rapidly, completing one rotation in 6.5 hours. This spin distorts Altair's equatorial diameter into twice that of its polar diameter.

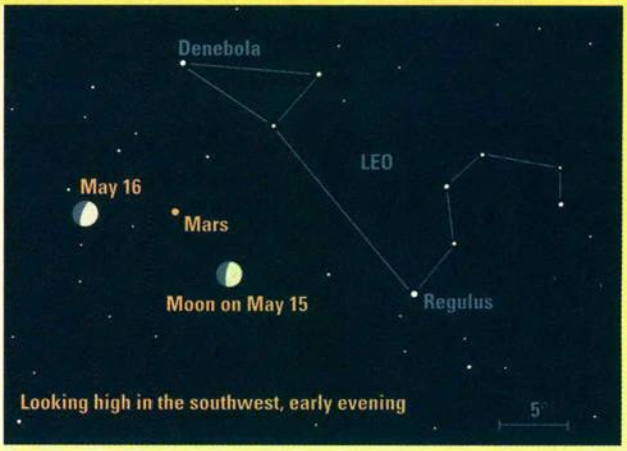
Altair forms the southern point of a famous asterism called the Summer Triangle. The Triangle's other two endpoints are magnitude-1.3 Deneb in Cygnus and brilliant magnitude-0.0 Vega in the compact group of Lyra. This trio lies in a section of the cloud-like Milky Way, which seems to waft up from the southern horizon in the hours before dawn.

Like any self-respecting bird of prey, Aquila is locked in a dive past Pegasus with a bead drawn on Pisces the Fish. As the sky begins to brighten, another quarry, magnitude-0.7 **Saturn**, rises in the east just below Delta (δ) Piscium.

Saturn's rings are tilted 10° to our line of sight, revealing their southern face to view. Those not up to early-morning observing can enjoy a midmorning occultation of Saturn by the moon on May 4.

Mercury reappears in the morning sky during the second week of May, far below Saturn and hugging the eastern horizon shortly before sunrise. On May 22, the morning of its greatest elongation from the sun, this elusive planet lies just 5° high 30 minutes before sunrise. This is its

Mars Lingers at Sunset



Looking high in the southwest, early evening

ASTRONOMY: Terri Metzger

We are now in the twilight of Mars's 1997 apparition. Earth has rounded the inside curve of a solar system racetrack and is pulling ahead of the Red Planet. Mars shrinks and fades as we leave it behind, 7 light-minutes away. Still, there are plenty of things worth watching with the naked eye or through a telescope this month.

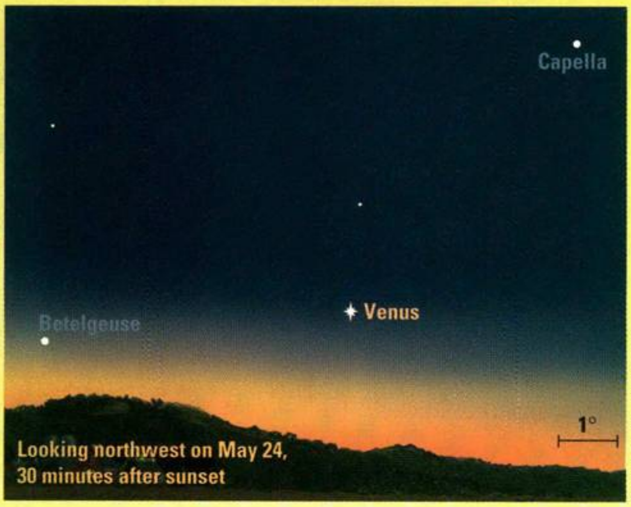
Mars lies due south during evening twilight, well placed for observing. Notice its brightness fade. Mars starts May at magnitude –0.4 and finishes the month at 0.2. Compare the planet's waning glow with the nearby blue-white star Regulus: Mars is not just a full magnitude brighter, its color is also distinctly ocher.

If you've been regularly observing Mars through a telescope this spring, you'll feel right at home with the shrinking disk, which drops below 10" in diameter this month. At this size, it's important to take advantage of any steadiness our atmosphere offers. Experience shows that seeing conditions are often best right at sunset.

The most obvious telescopic feature will be Mars's blazing white north polar ice cap, which is shrinking in size as the martian summer progresses. Then there's the dark, triangular form of Syrtis Major. Both of these sights are visible in a 4-inch telescope. For details on what else you can view, consult the article on how to observe Mars in last March's issue of ASTRONOMY. — *A. L.*

First Glimpse at an Evening Star

William Duffy, Jr.



Looking northwest on May 24, 30 minutes after sunset

ASTRONOMY: Terri Metzger

The month of May sees brilliant Venus return to her throne of "evening star." After a winter of accompanying us on our morning drive to work, our sister planet avails itself for any upcoming romantic summer evening walks. The approaching evening apparition will carry us through the end of 1997.

Venus is now emerging from the far side of the sun as seen from Earth, so its climb up away from the sun's glare will be slow. At midmonth you'll need binoculars and an unobstructed western horizon to bag the planet, which shines at magnitude –3.9 and stands 4° above the horizon 30 minutes after sunset.

By the end of May, the Evening Star ekes its way up to a point where it twinkles 7° above the horizon 30 minutes after sunset. Try glimpsing it with the unaided eye after finding it in binoculars. As the dog days of summer approach, Venus will blaze brighter into the late evening, once again releasing an inevitable torrent of UFO sightings. — *A. L.*

worst appearance of the year for Northern Hemisphere observers.

Top off your morning observing with early May's Eta Aquarid meteor shower. Predawn hours are always the best time to watch any meteor shower because that's when Earth's leading edge plows directly into a meteoroid swarm. The Eta Aquarid radiant rises an hour or two before dawn, so observers have a chance to view meteors that skim our atmosphere and leave luminous paths called trains. Keep an eye out for occasional fireballs.

This shower has special significance, for Eta Aquarid meteors come from stuff left behind by Comet Halley in its orbit around the sun. One other meteor shower, the October Orionids, is also associated with Halley. □

Martin Ratcliffe directs the Henry Buhl, Jr. Planetarium in Pittsburgh, Pennsylvania. Alister Ling is a meteorologist for Environment Canada in Alberta.

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LUMICON Rich-Field Viewer	**$99.50**
Giant Rich-Field Viewer (10-14")	**$250.00**

Optional Eyepiece	**TRUE FIELD**	**Price**
Meade 32mm Plossl	1.4°	**add $99**
Meade 32mm 2" Wide-Field†	1.9°	**add $459**
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†Includes 2" enhanced aluminum Star Diagonal (may not reach focus on some telescopes).

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Protect your valuable telescope optics, eyepieces and accessories with these black vinyl covers. Add $1 shipping. Deduct 10%, 2 or more sets.

1¼" O.D. plug, seals focuser	**4/$2**

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2"	**2/$2**	12½", 12⅞"*	**$20**
2⅛"	**2/$20**	15.0", 15.6", 16"*	**$28**
5½"	**$6**	19" (DS-16)	**$35**
*Fits Odyssey		21" (Odyssey-II)	**$35**

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16" LX200 $14,950

Meade 8" LX200 Telescopes

LX50 - includes dec. motor, hand controller.
LX200 - full computer control w/64K obj. mem.
Tripod: extra for LX50; included for LX200
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NEW! 3.5" f/14 ETX Maksutov ($20)	**$595**
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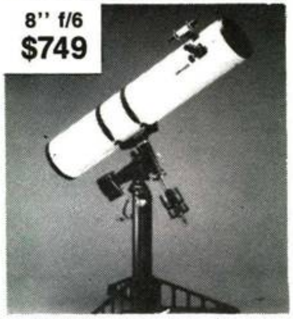
Giant EASY-GUIDER for 10"/12" f/4-f/10	**$395**

MEADE STARFINDERS

8" f/6
$749



New 8" f/6 Meade Starfinder telescopes

See the Meade ad in this magazine for full descriptions. These are complete telescope systems with motor drive & finderscope (equat. only), mount, and 25mm (=48X) eyepiece. New DC motor runs on 4AA batteries.

6" f/8 Dobsonian Starfinder ($46 P&S)	**$319**
6" f/8 Equat. Starfinder 6(add $79 P&S)	**$649**
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8" f/6 Equat. Starfinder 8 (add $89 P&S)	**$749**
10" f/4.5 Dobsonian Starfinder ($85 P&S)	**$599**
10" f/4.5 Equat. Starfinder 10 (add $99 P&S)	**$879**
12.5" f/4.8 Dobsonian Starfinder ($95 P&S)	**$895**
16" f/4.5 Dobsonian Starfinder (freight COD)	**$1195**
16" f/4.5 Starfinder 16 (ship. freight COD)	**$2695**

*All Starfinder telescopes shipped directly from Meade to the purchaser. Please add the indicated packing & shipping charge to the price. Slightly lower P&S for payment by check. LUMICON showroom prices are $50-$100 higher.

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Magellan computer; specify Dob. or Eq. ($15 ship)	**$295**
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- Polar alignment ***not required!***
- Motor drive ***not required!***
- Just sight two stars to align!
- Works **equally well** for alt-azimuth telescopes like Coulter Odyssey and equatorial mounts like C-8, Meade 2080.
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Ultima 8, 9¼, 11 **add $25**, C-14 **add $75**

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Coma 1 inch off-axis 17½" f/4.5

Same field with LUMICON coma corrector; smaller, more numerous stars.

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LUMICON 48mm Coma Corrector/Field Flattener Lens	**$285.00**
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2" EASY-GUIDER (Mamiya 645)	**$239.50**
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New! Thread-on for Odyssey

FROM $69.50

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Select your desired base-plate shape!
Coulter Odyssey (thread-on installation), Flat, 7" OD, 9½" OD, 12½" OD, 16" OD, 21" OD.

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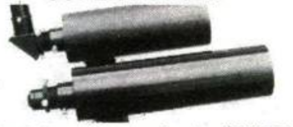

Visual Astronomers prefer the LUMICON 80mm SUPER-FINDER™, since hundreds of deep-sky objects, including most Messier objects, are visible directly. SUPER-FINDERS also make nice small portable telescopes. 80mm aperture, F=300mm coated achromat or 50mm, F=200mm coated achromat. Eyepieces and/or star diagonal are extra.

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**Threaded to hold 48mm filters.*

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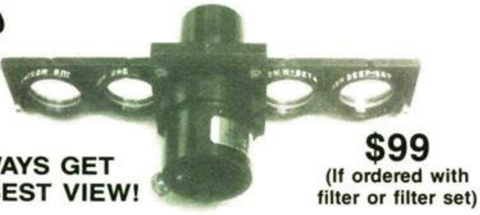

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Helix Nebula, NGC 7293 in Aquarius. Bright and easy with Lumicon Oxygen-III Filter.

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Rich Zepernick, Cresskill, NJ

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BEST for Astrophotography!

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Choice of ***any two*** LUMICON filters (**Save 7%**) 1¼" **$185.00**; 48mm	$370.00
LUMICON H-BETA Line Filter (9mm bandpass at 486nm). For the California Nebula, Horsehead Nebula, and other extremely faint nebulae. **1¼" $99.50, 48mm**	$199.50
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Universal adapter for 1¼" filters. Adapts the 1¼" filters to any 1¼" eyepiece	$19.50
Universal adapter for 48mm or 2" filters. Allows use of any 1¼" eyepiece	$25.00

**Premium filters are currently the best in the world. All Lumicon filters include individually measured transmission data.*

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The LUMICON adjustable piggyback mount is ideal for telescopes of 6-16" aperture. It permits **both** vertical and sideways adjustment for optical alignment. Also ideal to mount LUMICON 80mm SUPER-FINDER™, large telephoto lenses and small telescopes up to about 5 lbs.
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Specify telescope size: 6", 8", 10", 11", 14", 16"

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Yields spectacular contrast gains in B&W photograph with telephoto lenses. Yields pinpoint star images. Superb with hypered 2415. For color, use the LUMICON Deep-Sky (DS) Filter.

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52, 55, 58, 62mm	**$69.00**	**$199.50**
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Hypered 2415 film, 36 exp .. **$11.95, $3/$32**

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DEEP-SKY ASTROPHOTOGRAPHY

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†U.S. Patent 4,473,636

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All **LUMICON EASY-GUIDER™** off-axis guiders† have both radial and 360° rotational adjustments for 5X easier guide-star selection, use 48mm filters, 360° camera rotation, large prisms for bright guide-stars. †U.S. Patent 4,448,500
Specify Camera and Telescope type.

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Full aperture. Installs in seconds. Specify 2" or 1¼".

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Fuji G800 fine grain color neg.	**24**	**$13.95**
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Southern Skies Hoard the Giants

A treasury of giant globulars lies buried in the south.

by Richard Jakiel

Few objects inspire more awe and wonder through a telescope than globular clusters. Seeing thousands of faint stars crowded in a small region, often with a striking "three-dimensional" effect, can leave a life-long impression. However, to the woe of Northern Hemisphere observers, the largest and brightest globulars heavily favor the Southern Hemisphere.

Unlike open clusters, these giant globulars are huge agglomerations of hundreds of thousands of stars, compressed into a spheroid one or more hundred light-years in diameter. Globular clusters are among the oldest known objects in our galaxy — 10 to 16 billion years old — so they formed during a very early stage of galactic evolution.

The spectacular Hercules Cluster (M13) almost pales when compared to the greatest of these southern giants. Its apparent brightness ranks it only eighth, and in size it falls back even farther — to 10th place.

Only a few of these outstanding clusters, such as Omega Centauri and 47 Tucanae, are well known. Not many northern amateurs even know of NGC 6397 and NGC 6752. Yet both objects are considerably bigger and brighter than M13, and each is beautiful in almost any size telescope.

We will begin our tour of the great southern giants with those visible during late winter and early spring. During this time, globular clusters of any kind are scarce, but far to the south lie two sparkling gems. **NGC 3201** in Vela is easily spotted in a finderscope. Start at 3rd magnitude Mu (μ) Velorum and swing the scope northeast to t Velorum. From here, move the scope about ¾° north and then due east 17'. Lying at a declination of –46.3°, this cluster is visible throughout most of the United States. Spanning 18.2', NGC 3201 is slightly larger than M13 but slightly fainter, at magnitude 6.8.

Antares, M4 Region

(4.7-inch f/8.5 apochromatic refractor, hypered Fujicolor 400 film, composite of 75-minute and 90-minute exposures)

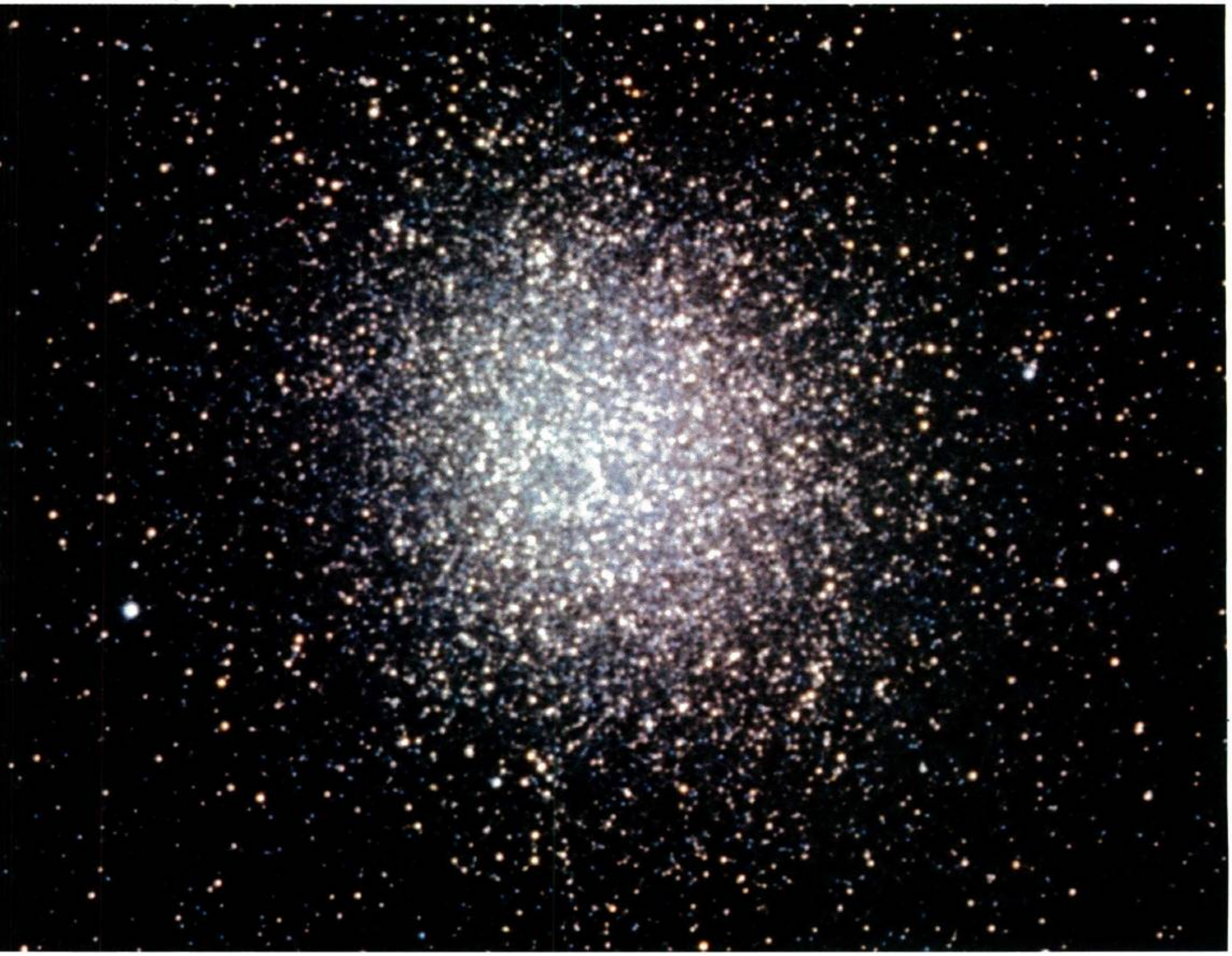
Luke Dodd

The Shapley concentration scale denotes how condensed a globular is. This scale ranges from I to XII, where I is the most concentrated and XII the least. NGC 3201 is a X, making it easy to resolve individual stars in even small backyard scopes.

Too far south to be viewed from the U.S. lies **NGC 2808** at declination –64.5° in Carina. Though only slightly brighter than NGC 3201, at magnitude 6.3, it appears substantially different. This highly concentrated class I globular spans 13.8' and lies nearly 5° due north of the bright star Beta (β) Carinae. Its many faint stars surround a blazing core. Viewing both clusters on the same night should quickly dispel the notion that all globular clusters look alike.

At a distance of 17,000 light-years, **Omega Centauri** is one of the most spectacular objects in the sky. It's an easy naked-eye target and its magnitude of 3.7 ranks it as the brightest globular cluster. Only its deep southern location (–47.5°) keeps it from being viewed by many northerners. It's also the largest globular cluster in our galaxy, spanning more than 600 light-years.

Omega has a concentration class of VIII, allowing for its stars to be resolved in the smallest backyard



Andrew Peters

Omega Centauri (NGC 5139)
(20-inch f/5 reflector, hypered Fuji 400 film, 13-minute exposure)

scopes. Omega is massive — it covers more than four times the area of M13. Spanning 36.3', its area is larger than the full moon. Long exposure photographs extend its dimensions to more than 65'.

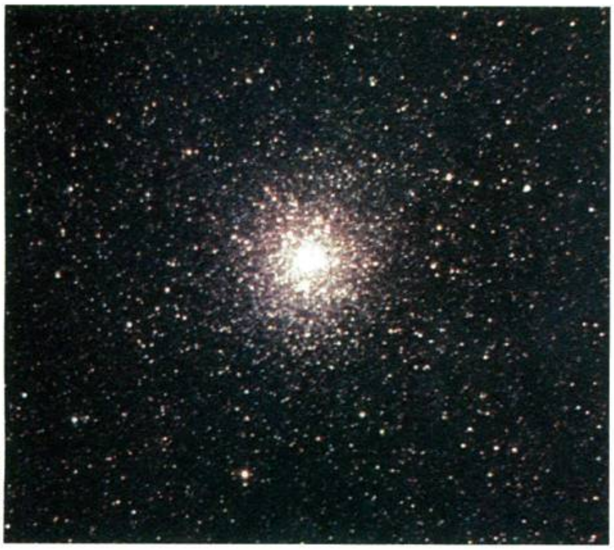
Even at low power through a 20-inch f/6 scope, Omega spans nearly 30', overflowing the field with an incredible multitude of tiny diamond points. Its texture is unusual, as it appears to have dozens of short star chains radiating outward from the center like the tentacles of a sea anemone. Omega is worth more than a casual look — observe it with a variety of scopes and magnifications.

When viewed high in the sky, **M4** (NGC 6121) in Scorpius has few rivals. But for northern observers, atmospheric extinction and summer haze take a toll. M4 measures 26.3' in diameter; only Omega and 47 Tucanae are larger. The honor of the closest globular goes to M4. A mere 7,000 light-years distant, it is one of the easiest globulars to find and observe, lying only 1.5° due west of the brilliant star Antares. With a magnitude of 5.9, and coupled with a Shapley class of IX, this cluster's stars can be resolved in even a 3-inch scope. The most striking feature is a peculiar double line of 11th- and 12th-magnitude stars which runs north-south and neatly bisects the cluster. Challenge yourself — what is the smallest instrument that reveals this feature?

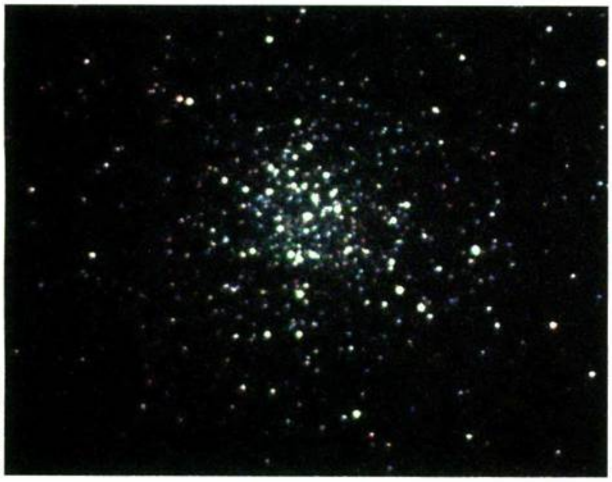
NGC 6397 in Ara ranks a close second in the distance race. Some 7,200 light-years away, this striking cluster is a close twin to M4, as they both have the same condensation class (IX) and very similar sizes and magnitudes.

For many observers, the easiest way to find this globular is to locate the stars Beta (β) and Gamma (γ) Arae, then shift the scope about 2° northeast to Pi (π) Arae. From here, it's a short 1° hop north-northeast. A 3-inch scope reveals dozens of faint stars. NGC 6397 is large and rich, with a bright, well-resolved core and outlying star chains.

The richest concentration of globulars in the sky lies north of Ara. Stargazers armed with a good star atlas and dark skies often observe dozens of globulars there. By far the most spectacular of these is **M22** (NGC 6656) in Sagittarius. It glows at magnitude 5.1 and straddles a robust 24.0' of sky.


Jack Newton

M22
(25-inch f/5 reflector, Ektachrome 400 film, 14-minute exposure)


Gordon Garradd

NGC 3201
(10-inch reflector, HI-SIS CCD camera, composite of 30-second red, 200-second green, and 240-second blue exposures)

A relatively northerly declination of –23.5° puts M22 in reach of nearly all northern observers. Locating it is easy — simply center Lambda (λ) Sagittarii in the field and star hop 2° northeast. In the smallest finder scopes M22 looks like a fat, fuzzy star; the cluster resolves easily into a myriad of stars through small backyard telescopes.

Perhaps the most neglected giant globular is **NGC 6752** in the constellation Pavo. The cluster's southern declination of –60° contributes to its obscurity. This globular rises just above the horizon in the Florida Keys, and is a prize for any observer who bags it. Shining at magnitude 5.4 and measuring over 20' across, this cluster ranks with many observers among the finest in the sky. Small telescopes begin to resolve this cluster into numerous 11th-magnitude and fainter stars. It is stunning — beautiful arcs of stars radiate away from a dense core. The prominence of these stellar "arms" led to the nickname "Starfish Cluster" from some Australian observers.

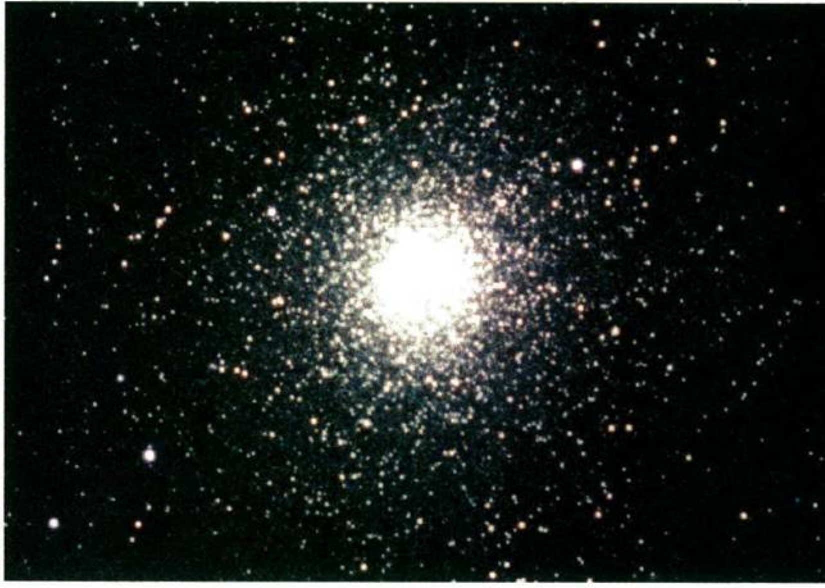
Two fine globular clusters flank the northern approaches to the Small Magellanic Cloud. Both lie below –70° declination, making them circumpolar objects for most of the Southern Hemisphere. One of these, **47 Tucanae** (NGC 104), challenges Omega Centauri as the most spectacular in the sky. Looking like a fat, 4th-magnitude star, it was given a stellar designation before its character was known. Using the SMC as a guide, it is perhaps the easiest globular in the sky to find with the naked eye. Only slightly inferior to Omega in brightness and size, 47 Tucanae has a different general appearance.

For starters, it has a Shapley class of III — much more compressed. Even in a small scope, the brilliant core is striking. Through a rich field telescope, I saw hundreds of 11th- to 12th-magnitude stars surrounding a dense, unresolved central mass. The cluster spans more than 20' and photographs increase its size to more than twice that. When viewed to full advantage in large backyard scopes, I consider this globular to be the most beautiful in the sky.

This list of southern giants is by no means complete, and with a little time and a good atlas you will be able to locate other bright clusters. When you view these impressive giants, spend some time using different magnifications and telescopes. Note the clusters' general appearance and any unusual structures that may be visible. Make note-taking and sketching a part of your general observing routine. In the end, you'll be rewarded by becoming a better observer, and you'll have both mental and physical records that can last a lifetime. ☐

Richard Jakiel has been an avid deep-sky sketcher for almost 25 years. He recently won the 1996 Graphics Award from the Webb Society, a British organization dedicated to deep-sky observing.

47 Tucanae (NGC 104)
(4.7-inch f/8.5 apochromatic refractor, hypered Fuji 400 film, 30-minute exposure)


Luke Dodd

The Great Nebula in Orion, M42

A

Kodak's Ektapress Multispeed 640

Film

captures deep-sky targets

for all

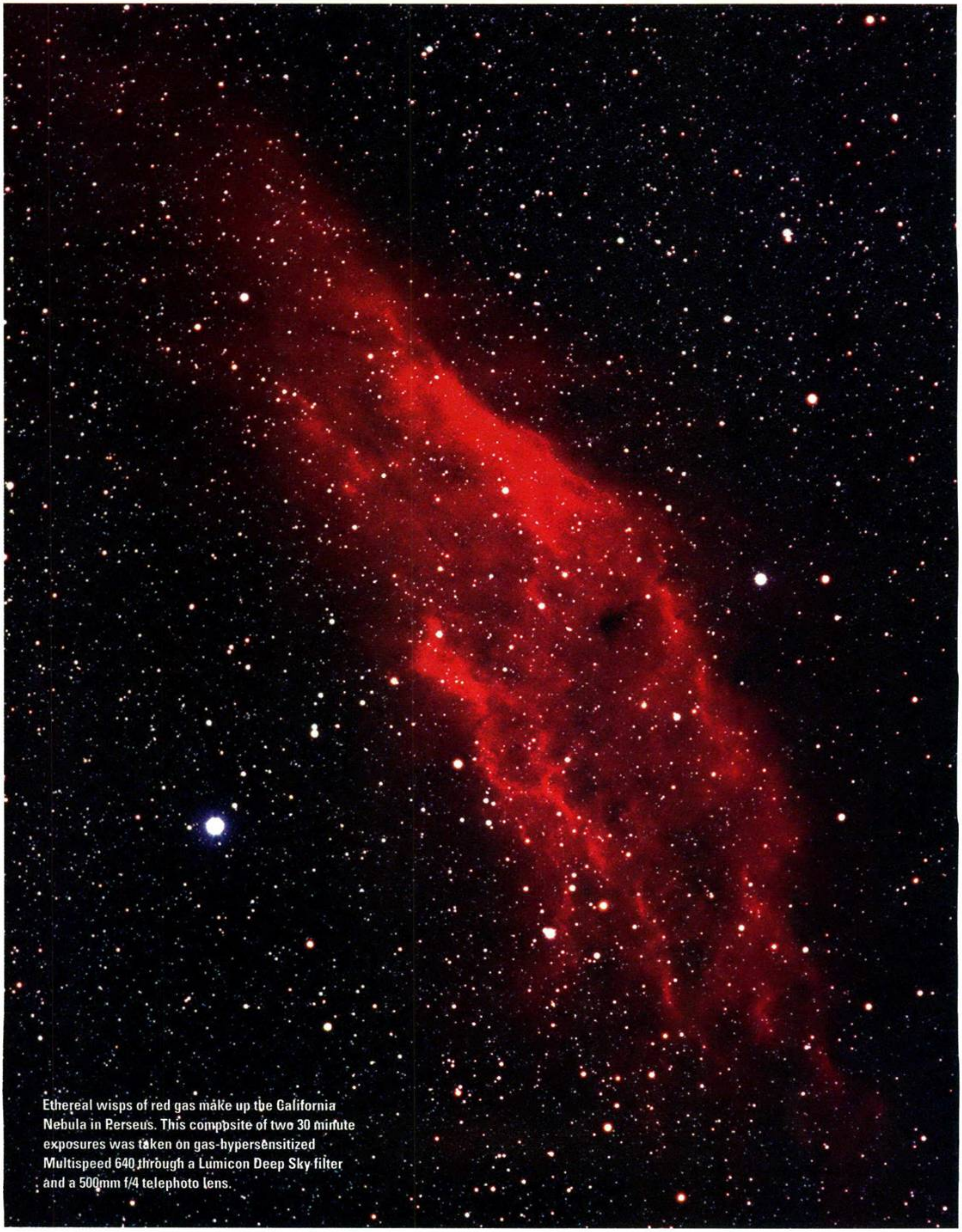
in a whole new light.

Nebulae

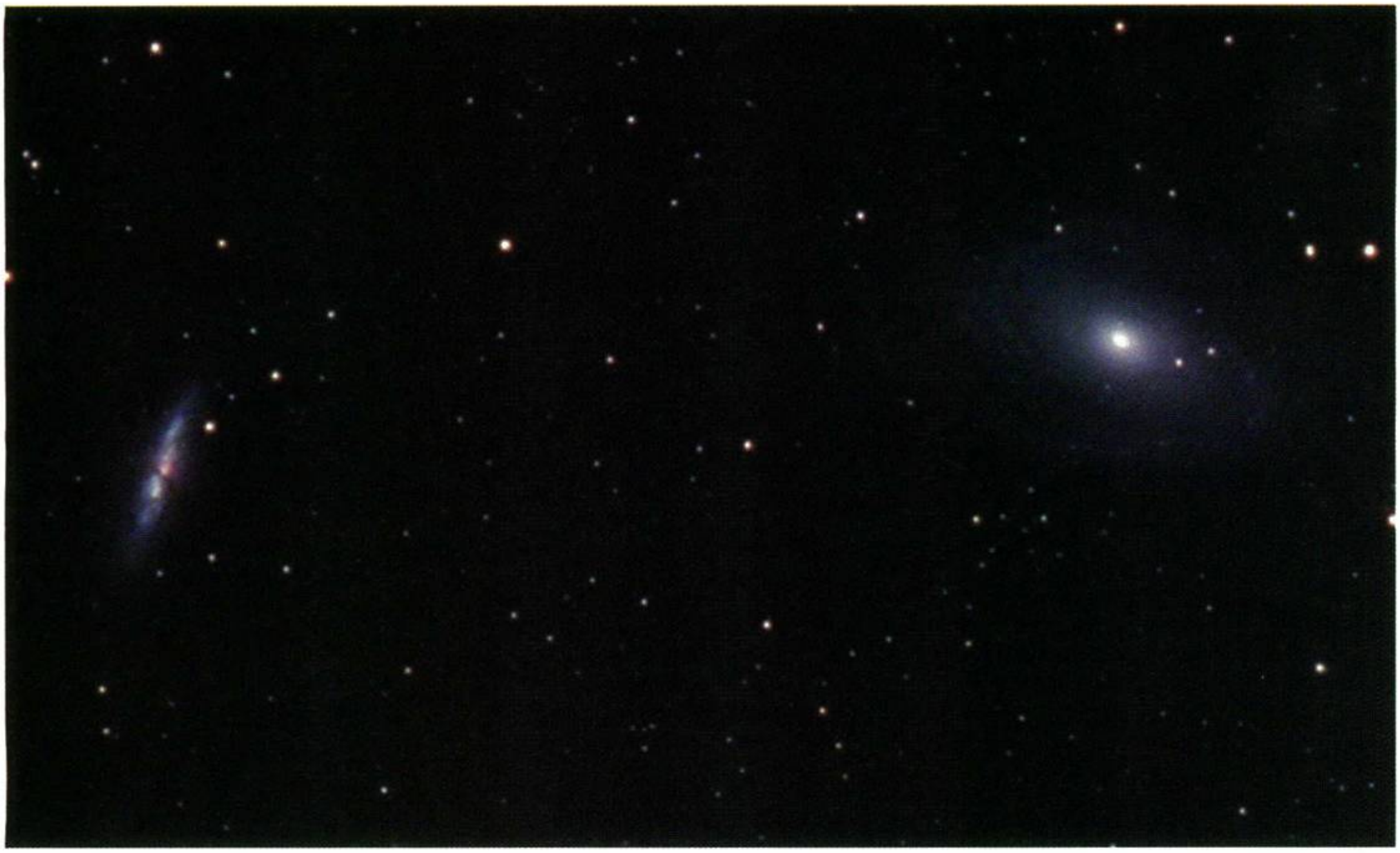
Story and photos by Jerry Lodriguss

Sometimes you just stumble onto a great astrofilm. Last September a Kodak sales representative handed me a couple of rolls of Kodak's new ISO 640-speed Ektapress Multispeed 640. The film had been sold in Europe for a number of months under the Gold II Multispeed label, and was just being introduced to the North American market. My rep probably thought I was going to try the stuff at a football game. Little did the guy know I was going to test it under the stars on deep-sky photography!

Well, test it I did. Ektapress Multispeed 640, also referred to by its three-letter code PJM, shows remarkably even sensitivity to blue and red light. This makes it useful over a wide range of deep-sky objects. The film also stands up to reciprocity failure, a bugaboo that often reduces a film's light-gathering power over long exposures. For example, I found Multispeed 640's true speed at five minutes was just about the same as another



Ethereal wisps of red gas make up the California Nebula in Perseus. This composite of two 30 minute exposures was taken on gas-hypersensitized Multispeed 640 through a Lumicon Deep Sky filter and a 500mm f/4 telephoto lens.



popular astrofilm, Fujicolor Super G 800 Plus.

A Contender in the Starlight

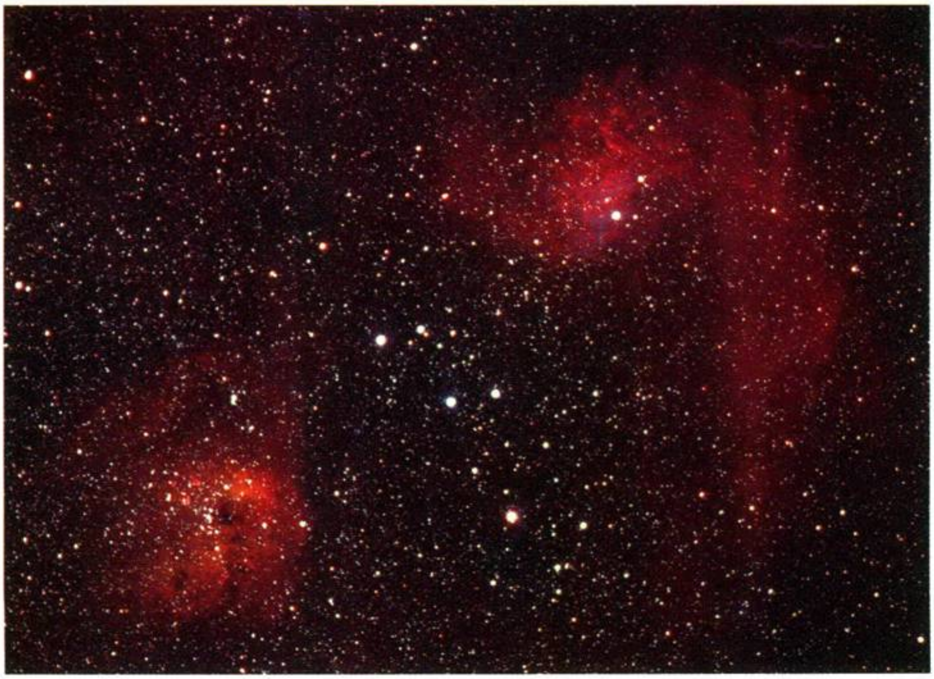
For my initial tests I took a 5-minute exposure of two deep-sky objects in Perseus, the Pleiades and the California Nebula, on unhypered Multispeed 640 through an 85mm lens working at f/2.8. (Hypersensitization, also called "hypering," soaks a film in a mixture of nitrogen and hydrogen gas to boost an emulsion's sensitivity to low levels of light.)

Nebulosity that surrounds the Pleiades shines blue in reflected starlight. Consequently, it served as a good test of Multispeed 640's blue sensitivity. The California's predominantly red glow caused by the ionizing radiation of nearby hot stars gauged the film's red response.

For comparison's sake, I made similar exposures on hypered and unhypered PPF-2, hypered Ektachrome E100SW, and unhypered Fujicolor Super G 800 Plus. These films represent the preferred emulsions for most astrophotographers.

A distant galaxy's starlight mingles with the red of its glowing gas clouds and stellar nurseries (above). This 60-minute exposure of M82 (left galaxy) and M81 in Ursa Major was shot on hypered Multispeed 640 film through a 5.2-inch f/8 refractor. Both galaxies lie about 7 million light-years from Earth.

The Flaming Star Nebula, IC 405 in Perseus (below), comes alive with shades of red nebulosity. Note the orange glow in IC 410, to the left of IC 405's noticeably redder nebula. This image is a 30-minute exposure on gas-hypersensitized Multispeed 640 taken through a Deep Sky filter and a 500mm f/4 telephoto lens.



Turbocharging Multispeed 640

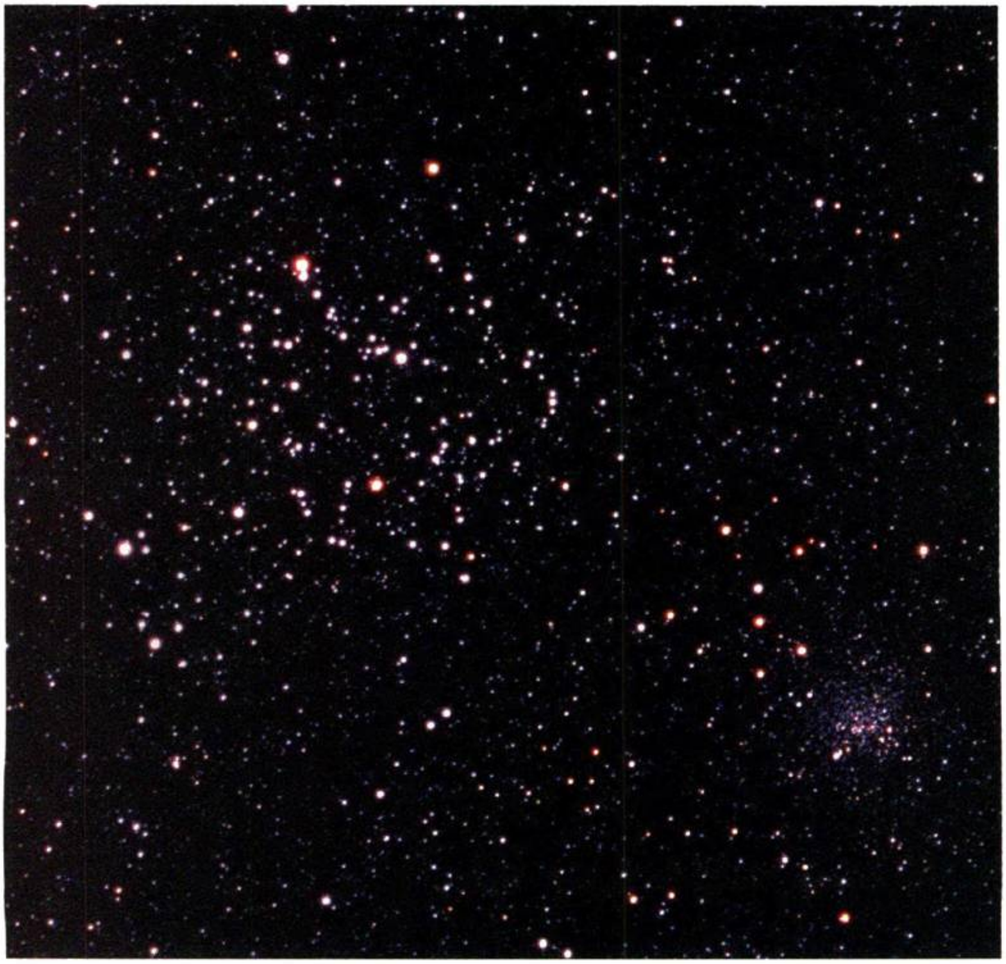
Backyard astrophotographers borrow a technique from professional astronomers when it comes to boosting film efficiency. Hypersensitizing, or hypering, film in a tank filled with a warm mixture of hydrogen and nitrogen gas makes it record fainter light more efficiently over long exposures. The hypered Multispeed 640 I tested was treated in a Lumicon Model 300 hypering chamber with standard forming gas (92 percent nitrogen, 8 percent hydrogen) at 50° C for 12 hours. I evacuated the tank with a hand vacuum pump to –27 psi and refilled with forming gas three times. On the third refill, the tank was topped off to 3 psi. Hypering took place with the film in its original canister, not rolled onto a developing reel. Twelve hours of hypering yielded a film base fog of 0.10 above unhypered film, which is my goal for hypering any color negative film.

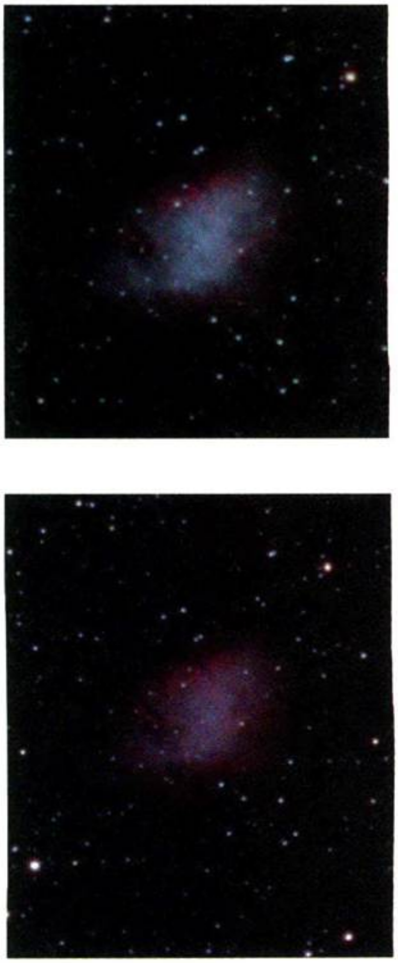
As I expected, all of the films in my comparison responded well to blue light; the Fuji 800 was more sensitive than the other two emulsions, but only slightly.

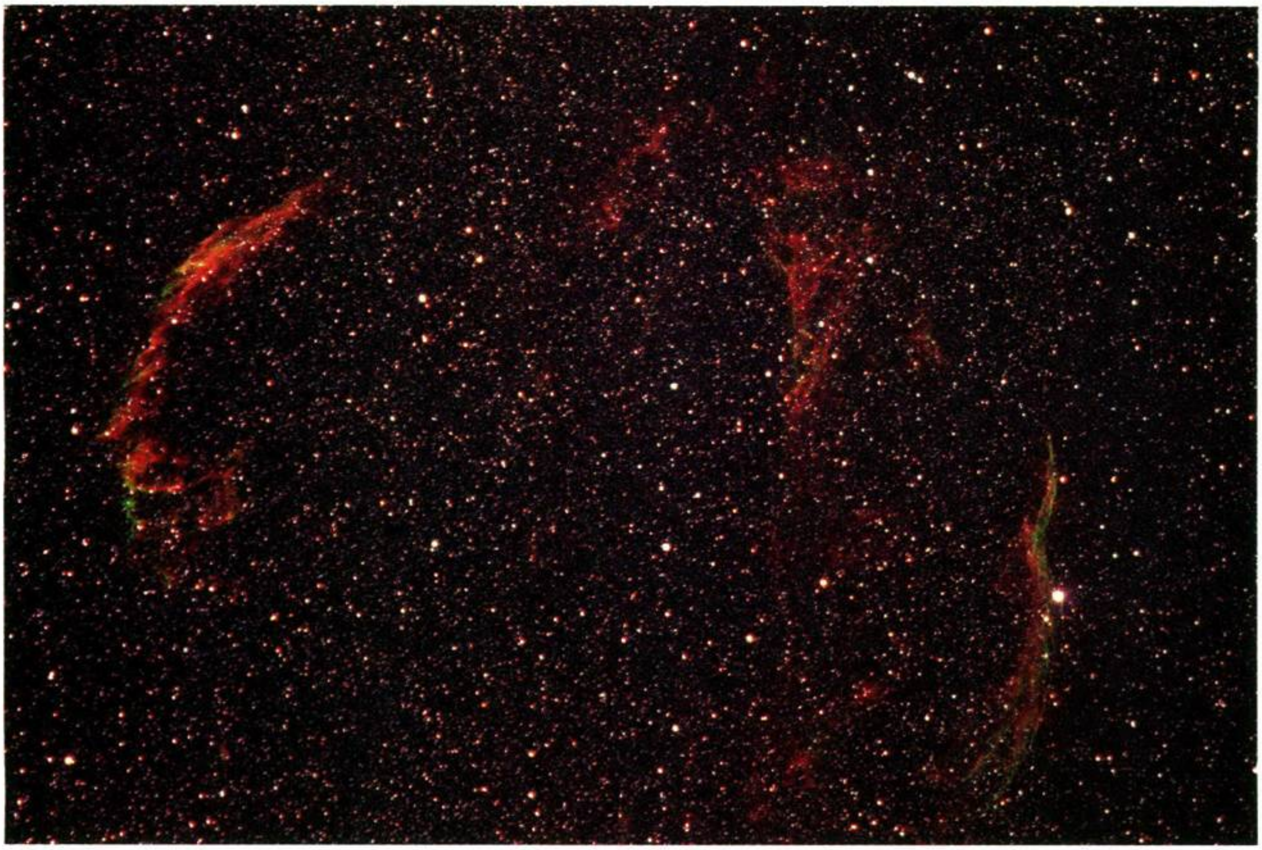
When it came to the ever-important red response, though, the Fuji was the worst of all films tested. On the other hand, Ektapress Multispeed 640 was undeniably the winner in recording red light, easily yielding the best rendering of the California Nebula.

My second field test was with hypered Multispeed 640 film. On the first clear night, I packed up my equipment and drove about three hours to a dark-sky site called Promised Land State Park. There I shot the Veil Nebula in Cygnus through a 500mm f/4 lens and a Deep Sky filter.

Multispeed 640's high resolution lets stars show up as pinpoints in NGC 2158 (below), a companion open cluster to M35 in Gemini. This 30-minute exposure was made through a 5.2-inch f/8 refractor on gas-hypered Multispeed 640 film. This new film also records more well-known objects differently. The Crab Nebula in Taurus highlights this through comparison with another favorite astrofilm, Fujicolor Super G 800. Bluish-green features come through in a 60-minute photo on Fujicolor 800 (below), while more red nebulosity gets picked up in 50 minutes by Multispeed 640 (bottom). Both photos were taken through a 5.2-inch f/8 refractor, with the Multispeed 640 being gas-hypersensitized and the Fujicolor Super 800 remaining untreated.







A range of greens, yellows, oranges, and reds shine through in this image of the Veil Nebula in Cygnus taken on gas-hypersensitized Multispeed 640. This is a composite of two 30-minute exposures through a Deep Sky filter and a 500mm f/4 telephoto lens.

When the negatives came out of my developing tank, I nearly fell on the floor. As you can see in the photo above page, Multispeed 640 recorded an amazing amount of nebulosity in the Veil, including some faint tendrils in what deep-sky observers call Pickering's triangular wisp. All the more astonishing was the color saturation of green, yellow, orange, and red nebulosities.

Astrophoto Nirvana

Along with Kodak PPF-2, last year's serendiptous discovery, and that old standby, Fuji's Super G 800 Plus, it now appears we have a third great film for deep-sky photography. Ektapress Multispeed 640 delivers spectacular results.

The film records the reds we see in most of emission nebulae extraordinarily well, even better than PPF-2. It does not seem to record blue nebulosity quite as well as Fujicolor Super G 800 Plus, but I only did one brief test on the reflection nebulosity surrounding the Pleiades. I'd be curious to hear other astroimagers' opinions of Multispeed 640's blue performance.

I've also only managed to test the film on galaxies with a shot of the M81 and M82 galaxy duo in Ursa Major. My field testing is scheduled to pick up again when these and other galaxies in the spring sky swing into view. If experience holds, I have a hunch Multispeed 640's performance won't disappoint me. □

Where to find Ektapress Multispeed 640

Kodak Ektapress Multispeed 640 color negative film has been available in Europe under the Ektapress Gold II Multispeed label. Kodak's Ektapress line of films is primarily aimed at the professional photojournalist market in five packs. Don't expect to see it in chain department stores. Look for Ektapress instead at most camera shops that supply professional photographers. That failing, try some of the major photography supply houses that advertise in this and many other photography magazines. The author obtains film from B&H Camera in New York City (800-947-7785), Abbey Camera in Philadelphia (215-236-1200), and Pittman Camera in Miami (800-252-3008).

Jerry Lodriguss is a photojournalist in New Jersey. Check out his web site at http://www.astropix.com or e-mail him at jml@astropix.com.

Grab a Rock

Starting a meteorite collection can

Text and photos by Jim Phillips

Ever since I was a child, I wanted to own a meteorite, a rock from outer space. That opportunity came many years later, while I was on vacation in West Virginia. I walked into a gift shop one afternoon and couldn't believe my eyes. There in a glass case was a meteorite for sale, a meteorite as big as my fist! It was a Canyon Diablo, an iron meteorite, a portion of the monstrous rock that struck Earth 20,000 to 50,000 years ago, forming the great Meteor Crater in Arizona. I've been hooked on meteorites ever since. It's a thrill to own material that tells the story of the solar system's formation. You too can experience this same feeling by starting your own meteorite collection.

Ancient Rocks

Meteorites originate in the solar system, although some appear to contain interstellar grains. There are 11 documented meteorites of lunar origin and 12 that came from Mars (the SNC meteorites), including the now-famous ALH84001, which might contain ancient martian fossils. One rare group may even originate from comets. However, most meteorites originate in the asteroid belt. In fact, the chemical composition of specific asteroids matches that of some meteorites. For example, Vesta may be the parent body of a specific type of meteorite, the eucrites.

To understand the various types of meteorites, where they come from, and what they represent, recall that the solar system formed from a dusty, gaseous nebula that began contracting some 4.6 billion years ago. As the solar nebula began to collapse, material heated up. Particulate matter melted, forming 1- to 8-mm-wide, spherical, silicate globules called chondrules. Chondrules, along with unmelted material, began accreting into small parent bodies. Some

A Canyon Diablo iron meteorite from the core of a parent body.

from Space

be rewarding and affordable.

Iron meteorites, from the cores of relatively large bodies.

Achondrites (stones), possibly from the surface of the asteroid Vesta.

of these bodies were so small that there was no geologic processing of their constituent material. These small bodies collided with one another, causing some to fragment. Some of the material reached Earth as chondrite meteorites.

Larger parent bodies, those about 100 miles in diameter or larger, retained internal heat long enough to begin geological processing of material. These bodies differentiated into a crust, a mantle, and a nickel-iron core. They collided with one another and fragmented. Some of this material eventually reached Earth as well, giving us examples of the crusts, mantles, and cores of differentiated parent bodies.

There are three major categories of meteorites: the stones, the irons, and the stony-irons. Stones are further divided into chondrites and achondrites. Both chondrites and achondrites are composed mostly of silicates, the difference being that chondrites generally have chondrules while achondrites generally do not. Actually, one rare achondrite does have chondrules and there is one chondrite that does not have chondrules. Chondrites are all 4.5 billion years old, about the age of the solar system.

Chondrites are further divided into ordinary chondrites, enstatite chondrites, and carbonaceous chondrites. Ordinary chondrites are the most abundant meteorite type. They are subdivided into three classes: H-chondrites for high iron content (16 to 21 percent free metal), L-chondrites for low iron content (7 to 12 percent free metal), and LL-chondrites for very low iron content (less than 7 percent free metal). Chondrites are further classified according to how much they have been altered by heat and water.

Enstatite or E-chondrites are so named because they are rich in enstatite ($MgSiO_3$). Scientists think these meteorites formed inside Earth's orbit, possibly on Mercury or Venus.

Carbonaceous chondrites are primitive meteorites with a chemical composition closer to that of the sun than any other meteorite class. Many show evidence of the presence of water, and some contain organic compounds. Many carbonaceous chondrites have irregular, whitish calcium-aluminum-rich inclusions (CAIs). CAIs contain magnesium-26, an isotope that forms from the radioactive decay of aluminum-26 (which has a half-life of 720,000 years). Temperatures and pressures in the solar nebula were not high enough to produce aluminum-26, so scientists believe this isotope formed during a supernova explosion. Some astronomers think a nearby supernova triggered the collapse of the solar nebula and thus the formation of our solar system. CAIs provide direct evidence supporting this scenario.

Achondrites — the stones generally lacking in chondrules — have an igneous origin. They lack chondrules because they were once part of the crust of parent bodies large enough that the original silicate material heated up, melted, went through a liquid state, and was therefore geologically altered — destroying the chondrules. Thus, these parent bodies were large enough for the formation of magma. There are various types of achondrites based on chemical composition. The martian SNC meteorites are achondrites.

Iron meteorites represent the cores of large, differentiated parent bodies. As the material in a parent body heated up, the denser iron melted and sank to form the core. Irons, actually nickel-irons because they contain substantial amounts of nickel, are further divided into three categories based on the percentage of nickel present: hexahedrites (5 to 10 percent nickel), octahedrites (7 to 13 percent nickel), and ataxites (16 to 30 percent nickel).

Pallasite (stony-iron) meteorites, from the core/mantle boundary of large parent bodies.

Stony-iron meteorites represent the mantles of differentiated parent bodies. They are divided into two main groups: pallasites and mesosiderites. Pallasites are composed of crystalline olivine and nickel-iron. When nickel-iron sank to form the core of differentiated parent bodies, olivine crystallized at the core/mantle boundary with nickel-iron being somehow forced up between crystals. Mesosiderites, on the other hand, are portions of mantle that were fragmented and then reassembled.

In summary, large and small parent bodies formed in the early solar system. Chondrites represent portions of the smaller bodies that were not large enough for geologic processing to take place, so they represent the oldest material within the solar system that we can hold in our hands. Larger parent bodies heated up and differentiated into cores (nickel-iron meteorites), mantles (stony-irons), and crusts (achondrites).

Meteorite Dealers

Robert Haag Meteorites, P.O. Box 27527,
Tucson, Arizona 85726
Contact: Robert Haag
Phone: (520) 882-8804

Bethany Sciences, P.O. Box 3726,
Amity Station, New Haven,
Connecticut 06525-0726
Contact: Ron Farrell
Phone: (203) 393-3395
E-Mail: bethanysci@aol.com

Mineralogical Research Co.,
15840 E. Alta Vista Way, San Jose,
California 95127-1737
Contact: Eugene and Sharon Cisneros
Phone (408) 923-6800
E-mail: xtls@minresco.com

David New, P.O. Box 278,
Anacortes, Washington 98221
Contact: David New
Phone (360) 293-2255

American Meteorite Survey, P.O. Box
1003, Flagstaff, Arizona 86002
Contact: Steve Schoner
Phone: (520) 779-0688

Meteorite Market, P.O. Box 33873,
Juneau, Alaska 99803
Contact: Eric Twelker
Fax: (907) 789-3742
E-Mail: twelker@alaska.net
URL: http://www.alaska.net/~meteor

Killgore Southwest, P.O. Box 95,
Payson, Arizona 85547
Contact: Marvin and Kitty Killgore
Phone: (520) 474-9515
E-Mail: swmtlab@goodnet.com

Mitterling Meteorites, 5245 South Country
Club Road, Warsaw, Indiana 46580
Contact: Al Mitterling
Phone: (219) 269-4145
E-Mail: almitt@kconline.com

Collecting Meteorites

So why collect meteorites? First of all, don't collect something you love for its investment value. An investment has to be bought and sold without emotional attachment. Right now, Mars meteorites are *hot*. Based on what I paid for a piece of a martian rock, now would be the time to sell. Sell a piece of Mars? No way! Not me!

In addition, when you buy a meteorite for $100 and in two to three years it is selling for $150, you are faced with a dilemma. Should you sell it back to a dealer? Well, if the dealer is going to sell it for $150, he or she might offer you only $100 — there goes your profit. Should you try to sell it on your own? Who is going to buy a meteorite from you for $150 when he or she can buy it from a dealer with an established reputation for the same price? I think you should collect meteorites because you want to own a piece of extraterrestrial material, a piece of an asteroid, a portion of the oldest material in the solar system. Don't put your retirement fund into meteorites.

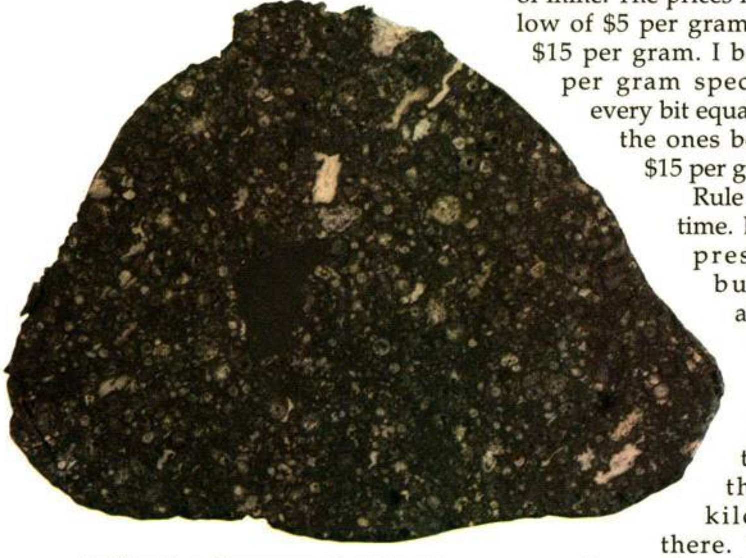
On the other hand, prices will probably go up. The number of collectors may be increasing due to the publicity associated with the Mars meteorites. As more collectors enter the market, prices could skyrocket. But more dealers may be entering the market as well. As there is no set way to price meteorites, new dealers may reduce prices on given meteorite types to get a share of the market.

A mesosiderite (stony-iron) meteorite.

Here is my advice for someone starting out, someone wanting to collect a meteorite from each of the three major categories:

Rule #1: Check with several dealers before buying anything. Prices may vary based on size, unusual surface features, and rarity of the meteorite type. Meteorites, for the most part, are sold by the gram. What a dealer charges depends on many things, including what he/she paid for the meteorite, what others are charging, and what buyers are willing to pay. There can be wide variation in what is asked per gram by different dealers, and no single dealer has all the highest or all the lowest prices. Recently, I asked a number of dealers for prices on Allende, a carbonaceous chondrite and a personal favorite of mine. The prices ranged from a low of $5 per gram to a high of $15 per gram. I believe the $5 per gram specimens were every bit equal in quality to the ones being sold for $15 per gram.

Rule #2: Take your time. Don't ever be pressured into buying right away. New meteorites are found with regularity and there are thousands of kilograms out there. With noted exceptions such as the Mars meteorites and other rare groups for the advanced collector, material representing all of the major categories is out there.



An Allende carbonaceous chondrite with calcium-aluminum-rich inclusions.

Rule #3: Prepare for the fact that meteorites weather and break down. That is why after billions of years of having Earth's surface pelted by meteorites, we can't just walk outside and pick them up by the bag full. Irons rust. They may need to be kept in air-tight containers along with a desiccant. I live in South Carolina, where I have a constant battle with rust. Even so, the best first meteorite to buy is a small iron, such as a Canyon Diablo, Odessa, or Gibeon. These meteorites are relatively inexpensive and readily available.

Finally, Rule #4: Plan your purchases with some overall goal in mind. Purchasing a meteorite or two doesn't require a large investment. But, as happened with me, collecting can be habit forming. Meteorites, particularly the rare types, can be very expensive. Keep in mind that gold is about $14 per gram.

Read about meteorites. Talk to dealers. Get copies of their price lists/catalogs and learn as much as you can. Remember the rules, devise an overall plan (single meteorite or small collection?), shop around, take your time, prepare for weathering, and enjoy an amazing opportunity to own a piece of extraterrestrial material, a rock from outer space! □

Jim Phillips is a pathologist with the Charleston Pathology Group in South Carolina. He is a former lunar recorder for the Association of Lunar and Planetary Observers.

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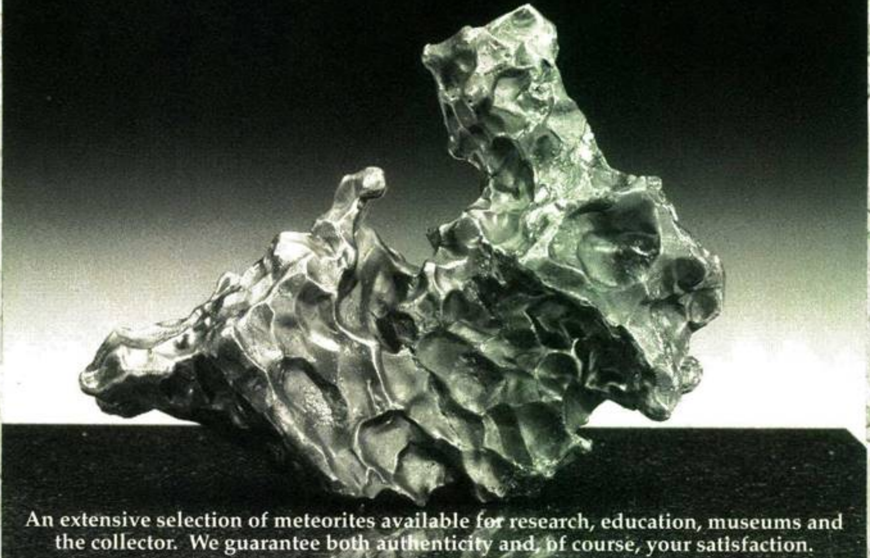

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Birth of a Skyshooter

Great astrophotos require tools like autoguiders and tricks you teach a telescope mount.

Story and photos by David J. Pontzer

Like many backyard astronomers who start out in this hobby, it didn't take me long to get the astrophotography bug. Visions of a hallway crammed with framed, glossy astro prints filled my mind. One print would show filamentary detail in the Veil Nebula, another, the prominent dust lane that runs through NGC 4565. And let's not forget those tiny Bok globules in the Rosette and, of course, the spiral arms of M74.

Well, years later, I'm finally getting those pictures. But the journey hasn't been what I thought it would be. It started out with a simple scope, only to lead to gizmos like autoguiders and mounts with features like TVC hysteresis compensation. Half the fun (and, frankly, the frustration) has been mastering advanced astrophotography techniques. Maybe you can learn from my journey.

Contributing to the GNP

My plunge into amateur astronomy started with a hint from my son about a telescope for Christmas. This was proof positive of a burgeoning interest in science, so I thought it was a great idea. Faithfully following the sage advice of an expert I met through work, my son and I first visited the stars with a beat-up pair of 7x50 binoculars. We learned how to use a star chart, found constellations, and, with tired arms and stiff necks, landed our first "faint fuzzy" in Hercules, the globular cluster M13. We were on a roll, so I ordered my son (OK . . . and me too) a 4.5-inch reflecting telescope for Christmas.

Christmas night found my excited son and me observing the spectacular sight of Jupiter at 130x. With a spring in my step, I began to refer to myself as a backyard astronomer. In keeping with this title, I spent more money on accessories.

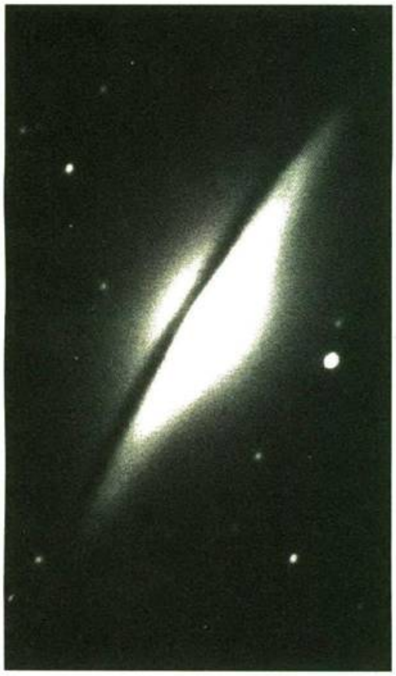
First there was a beefier 8x50 finderscope. Next came a couple more eyepieces, some color filters, a drive corrector, a polar alignment scope, and software for the computer. I was content at my credit limit, for soon the universe and all its vistas would land in my lap. And that of my son.

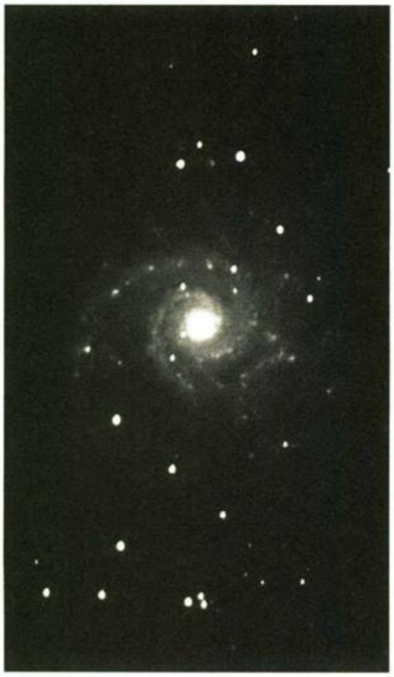
After conquering more than 30 Messier objects, my thoughts turned to astrophotography. Two more visits from UPS brought a used OM1 camera body and an eyepiece projection tube for high-magnification photography. We landed some great pictures of the moon, some "ho-hum" photos of Jupiter, and, let's be honest, some really lousy shots of deep-sky objects. I pondered why we weren't getting splashy images.

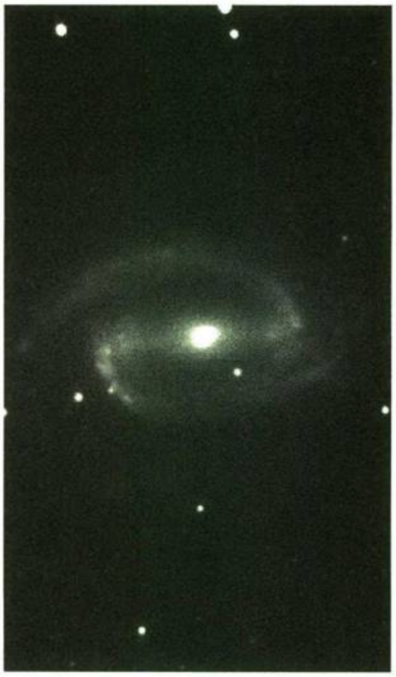
Fortunately, I'm at just the perfect age for a mid-life crisis. Several books, articles and catalogs later, I concluded that I needed more aperture, a rock solid mount with dual drives, and my own darkroom. Out went orders for an 11-inch Schmidt Cassegrain from Celestron, an off-axis guider from Lumicon, and a CCD autoguider called an ST-4, from Santa Barbara Instruments Group.

For the uninitiated, an autoguider electronically takes the place of your eyeball at a guiding eyepiece during one-hour exposures. It keeps the scope tracking accurately, courtesy of a light-sensitive CCD that monitors a guide star. The autoguider automatically controls a scope's drive motors to keep the star centered while you're off sleeping in the car or observing the heavens.

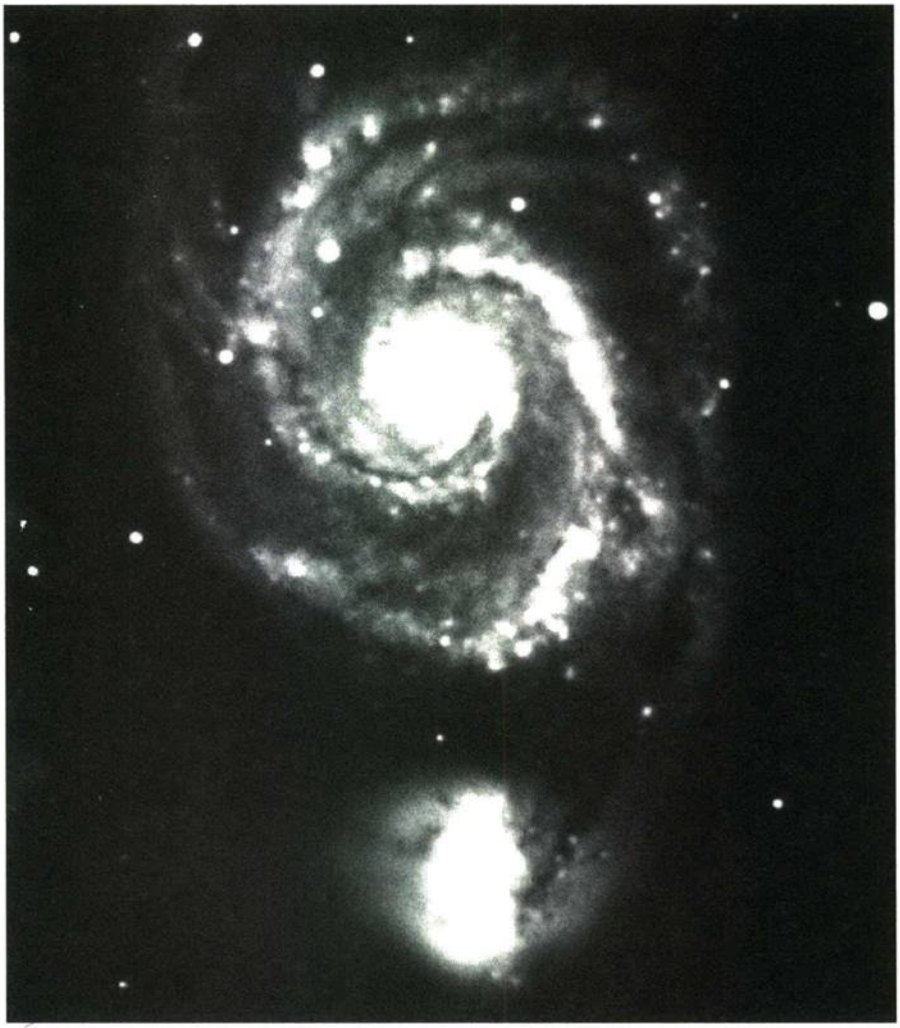
All told, this equipment cost me close to five grand. My wife took comfort in the fact that it would all fit nicely into the corner of our family room. She was also relieved that my obsession cost only a fraction of what our neighbor spent for his fishing boat.







A skyshooter finally lays claim to his own collection of galaxy pictures. The Sombrero Galaxy, M104 (left) lies in Virgo. Face-on spiral M74 (center) is in Pisces. The barred spiral NGC 1300 (right) shines in Eridanus. See the magazine's photofacts section for technical information on these photos.



The spring constellation Canes Venatici harbors the Whirlpool Galaxy, M51. It's a popular target for backyard observers and astrophotographers alike.

Travails with an Autoguider

So armed with some shiny-new astroequipment, I clambered past my neighbor's fishing rig and set everything up to conquer the world of astrophotography. What I found was new meaning for the word frustration.

First, the autoguider would not track. Then I couldn't find anything, much less focus, through the camera's viewfinder. So I did everything by the seat of my pants. I knew my first results would be far from perfect. But to add insult to injury, the negatives were badly fogged. So back to square one I went, determined to knock down problems one at a time until I got things right.

My first challenge was to find and focus a guide star for the autoguider. I discovered that without a computer, this was a task better left to someone with non-violent tendencies. Fortunately, I had access to an old PC perfect for the job.

The only remaining challenge was to blend my autoguider's capabilities with the telescope's drive electronics. For a few moments I suspected my lingering tracking problems might lie in the telescope mount. But, in the end, they proved to be the amateur in the amateur. Once I calibrated the ST-4 with my scope's drive electronics, the autoguider became a marvel of modern electronics.

Here are some field-tested tips I've come across since then:

Know which end is up. Orient the autoguider's CCD chip in right ascension and declination. This helps both man and machine keep directions straight.

Get focused. At first, focusing on a guide star will be a trial-and-error process that involves carefully sliding the autoguider in and out of the guiding eyepiece tube. A laptop computer will help you center and focus on the guide star's image. With some experience and a few marks on the autoguider's barrel, the computer can be left at home.

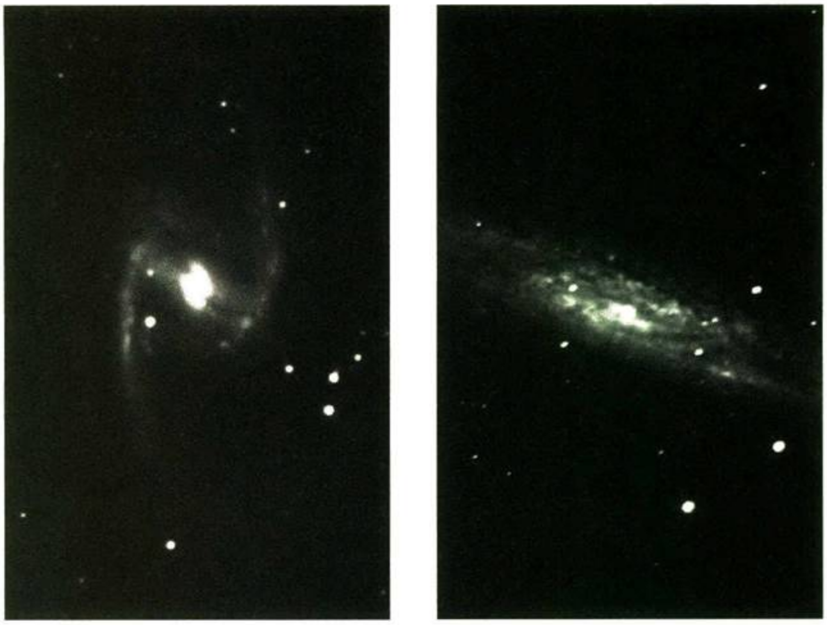
Adjust the gain. An autoguider's settings need to match the direction and speed of the drive motors on your telescope mount. For you ST-4 users, a guide star should move at least 20 counts during calibration. With my scope operating at f/5, both the C1 and C2 parameters should be set to 15. At f/10, a setting of 10 works fine. If a target lies near the celestial pole, the time for calibration in right ascension will be a bit longer.

Make the switch. This problem which vexed me for days applies only to people who use an ST-4. The ST-4 has an "fL" switch to accommodate longer focal length telescopes, such as Schmidt-Cassegrains, operating at prime focus. The factory setting of "S" should be changed to "L" unless a telecompressor lens is used.

Pace your autoguider. Adjust how often the autoguider corrects your scope's tracking. Longer times between corrections let the autoguider's CCD chip gather more light. This means you can track on fainter guide stars. However, it's best to keep the guiding update time as short as possible, especially on windy nights.

For the ST-4, an exposure time of one or two seconds seems optimum. I regularly use a "bA" setting of "faint" and a boost of two to achieve the minimum brightness level of 20 with a two-second exposure. If the guide star is too dim, update times as long as 10 seconds are workable, provided your drive is fairly accurate and the night air is calm.

Don't get twinkled. Autoguiders can trip up if they attempt to track a twinkling star. On nights of poor seeing, ST-4 users may want to set the "sA" parameter to 4 or higher, particularly if they are shooting at f/10. This will keep the ST-4's autocalibration feature from "chasing" a twinkling guide star.



Telescopes with mirrors as small as 8 inches will show NGC 1365's barred-spiral nature in Fornax (left) and NGC 255's clumpy, spiral appearance in Sculptor.

Step in to mediate. Every time I have tried a telescope drive's Periodic Error Correction feature with the autoguider, tracking accuracy seems to degrade. I suspect that the two control systems are "fighting" one another. Mediate by turning the PEC function off. Also, my Celestron has a "TVC hysteresis compensation" which controls a problem called "backlash" in the declination motor.

As part of your set-up routine, view a star through the guiding eyepiece and adjust the TVC setting until there's no choppiness to the star's declination motion. If push comes to shove, err on the side of some choppiness. Overcompensation with TVC can confuse the ST-4, which also has its own hysteresis compensation.

Get tight. Make sure that all thumbscrews are tight. Secure all the wires so they won't bump, slip, push, or pull at any time during a long exposure.

Get (un)balanced. German equatorial mounts must be balanced in declination. But here's a trick they don't teach in astrophoto school: Let the scope hang slightly out of balance and heavy to the east in right ascension. This ensures that the drive gears will always mesh and the drive motor will continuously push its load toward the west.

Let things warm up. Following calibration, start tracking and wait two or three minutes for the autoguider to auto-tune itself. On the best of nights, the error display of an ST-4 should hang around A2 or A3, with maybe an occasional A4 when shooting at f/5. At f/10, errors generally average between A4 and A6.

Sharpen up. You still might get pictures that are not centered or are out of focus. A camera's conventional focusing screen is made for daylight work, not for the low light you run into at night. Make sure your astrocamera has interchangeable focusing screens. Swap in what's called a Beattie focusing screen, specifically designed for astrophotography. They're sold by many astronomical suppliers. I also suggest Spectra Astro Systems' "Shure Sharp" and "Duo View" focusing aids. These devices and the proper focusing screen guarantee exact focus and composition by allowing you to see what's in the camera's field of view.

And Then There Was Film

Now it tracks, it focuses, it points at the right place . . . what else could go wrong? Plenty, if you shoot under humid conditions like I do. My first attempts taking pictures on hypered film (treated to boost its sensitivity, available from a company called Lumicon) resulted in badly-fogged negatives.

The culprit turned out to be the hot and humid Georgia night. Moisture was forming on the film inside the camera, especially where the pressure plate holds the film behind the shutter. Some foam board insulation on the camera body eliminated this problem. I also protect the film from moisture by placing a plastic bag packed with desiccant around the camera during the exposure.

Now that you have all the gremlins beaten down, or at least under control, open the camera's shutter, relax, drink coffee, write poetry, look at some binocular deep-sky objects, or sleep. All your patience and perseverance is about to pay off. It did with me.

Remember that hallway full of astroimages I envisioned way back when? It continues to grow, one picture at a time. □

Pontzer (dpontzer@surfsouth.com) manages advanced technology development for M&M/Mars in Albany, Georgia. At night he's is a avid backyard astronomer and astrophotographer.

A burgeoning interest in astronomy by Pontzer's son Scott (right) launched both father and son into astrophotography.

Get Ready to Party

The best sky show of summer could be near your hometown.

Star parties are a great way to combine family vacation with astronomical adventure. Pick a region of North America, and there's liable to be a party any time this summer under the dark of a new moon. Observe, listen to learned astronomers, or pick up a valuable piece of equipment at a swap meet. It's all yours for the taking. Keep an eye out on ASTRONOMY's Meetings and Events column for additions or updates.

June 1997

1 **May 30–June 1 (Waupaca, Wisconsin).** Wisconsin Observers' Weekend (WOW) 1997 offers observing under the state's darkest skies at Hartman Creek State Park. Write Don Wyman, 1065 Laager Lane, Oshkosh, WI 54901; e-mail, dwyman@vbe.com; telephone, (414) 233-3083.

2 **June 13–14 (Dayton, Ohio).** Telescope making contests, astrophotography judging, astronomy talks — it's all part of Apollo Rendezvous '97, organized by the Miami Astronomical Society at Dayton's Museum of Natural History. There's also a flea market, a mirror-grinding demo, and an astrophotography contest. Contact Wade Allen, 2600 Deweese Parkway, Dayton, OH 45414; phone, (513) 275-7431, extension 22.

3 **June 6–7 (Kenosha, Wisconsin).** The 50th Annual Convention of the North Central Region of the Astronomical League is hosted by the Racine Astronomical Society. An open house at RAS's observatory is followed by talks, displays, and a banquet at the University of Wisconsin's Parkside campus. Write the Racine Astronomical Society at P.O. Box 085694, Racine, WI 53408; e-mail, jmccrick@execpc.com.

4 **June 6–8 (Sussex, New Jersey).** Jersey Star Quest VIII, presented by the Amateur Astronomers' Association of Princeton near High Point State Park. Includes a Messier-hunting contest, a swap meet, door prizes, and astrophoto workshops. Write the AAAP at P.O. Box 2017, Princeton, NJ 08543; e-mail, wjm@sarnoff.com.

5 **June 6–8 (Shrewsbury, Pennsylvania).** The Mason-Dixon Star Party is put on by the York County Parks Astronomical Society at Spring Valley County Park, seven miles north of the Pennsylvania/ Maryland border and 15 miles south of York. For more information, write Jeri Jones, 400 Mundis Race Road, York, PA 17402 or call Todd Ullery at (717) 235-1153; e-mail, Ullery@act.org.

6 **June 7–14 (Grand Canyon, Arizona).** The Grand Canyon Star Party is cosponsored by the San Francisco Sidewalk Astronomers (SFSA), the Tucson Amateur Astronomy Association, and the National Park Service. Observe from Yavapai Point on the famed canyon's 7,000-foot North Rim. Contact Dean Ketelsen, 1122 East Greenlee Pl., Tucson, AZ 85719; phone, (520) 293-2855; e-mail, ketelsen@as.arizona.edu.

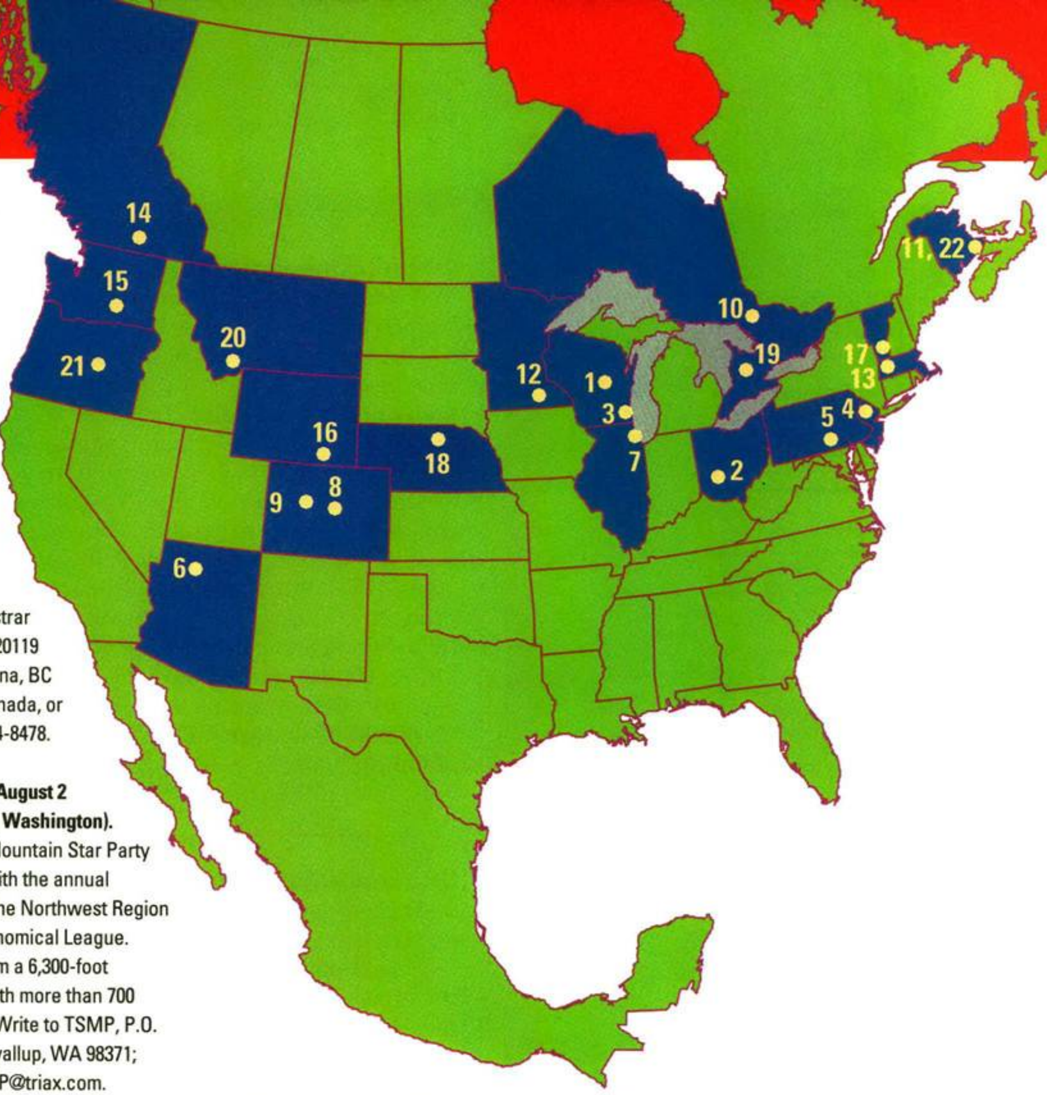
7 **June 27–July 2 (Chicago, Illinois).** ASTRONOMY magazine and the Astronomical Society of the Pacific present Universe '97. Hear professional astronomers and ASTRONOMY editors speak and tour the University of Chicago's Yerkes Observatory. Contact Universe '97, 390 Ashton Ave., San Francisco, CA 94112; phone, (415) 337-1100; fax, (415) 337-5205; e-mail, Ikeechler@ aspsky.org; website, http://www.aspsky.org.

8 **June 27–29 (Lake George, Colorado).** Confuse the Milky Way for clouds at the 11th annual Rocky Mountain Star Stare, sponsored by the Colorado Springs Astronomical Society. Write to RMSS'97, 8125 Avens Circle, Colorado Springs, CO 80920; e-mail, DWilder@kktv.com. Check out the Rocky Mountain Star Stare dedicated website at http://www.UCCS.edu/~cwetheri/Astro/CSAS/ RMSS97.html.

July 1997

9 **July 1–6 (Copper Mountain, Colorado).** The Astronomical League's Astrocon '97 has observing sessions, professional astronomers, and the University of Denver's observatory on 14,125-foot Mt. Evans. Contact

ASTRONOMY: John Shibley



Jerry Sherlin at (303) 680-6894 or e-mail him at sherlin@aol.com. Write ALCON '97, c/o Chamberlin Observatory, University of Denver, Denver, CO 80208-0202. See the website at http://www.du.edu/~pryan/alcon97.html.

10 July 4–6 (Powassan, Ontario). The North Bay Astronomical Society leases a private campground for Gateway to the Universe. Enjoy observing, talks, and a swap meet. Write Tom Ouellette, 221 Mulligan St., North Bay, Ontario P1A 3P4, Canada, or telephone (705) 474-7666.

11 July 4–6 (Alma, New Brunswick). Astro-Atlantic '97, hosted by the New Brunswick Astronomy Club, takes place at Fundy National Park. Talks are given by professional and amateur astronomers. Write Adrien Bordage, 390 Kingsville Road, Saint John, New Brunswick E2M-4T2, Canada; phone, (506) 635-3004; e-mail, teseven@nbnet.nb.ca.

12 July 25–27 (Austin, Minnesota). The Star Party meets three miles outside of Austin at the Cedar River Astronomy Club's observatory built by the city of Austin. Write Keith Snyder, 407 15th St., SE, Austin, MN 55912; phone, (507) 433-1903; e-mail, kdsnyder@wolf.co.net.

13 July 25–August 3 (Savoy, Massachusetts). The Rockland Astronomy Club presents its Sixth Annual Star Party and Family Camping Vacation at the Shady Pines Campground. Contact the Rockland Astronomy Club, c/o Don Urban, 73 Haring Street, Closter, NJ 07624-1709; e-mail, durban@aol.com.

14 July 30–August 3 (Mt. Kobau, British Columbia). The Mt. Kobau Star Party focuses on deep-sky observing, telescopemaking, and astrophotography. Write the MKSP Registrar at P.O. Box 20119 TCM, Kelowna, BC V1Y 9H2, Canada, or call (604) 764-8478.

15 July 31–August 2 (Ellensberg, Washington). The Table Mountain Star Party coincides with the annual meeting of the Northwest Region of the Astronomical League. Observe from a 6,300-foot mountain with more than 700 stargazers. Write to TSMP, P.O. Box 785, Puyallup, WA 98371; e-mail, TMSP@triax.com.

August 1997

16 August 1–3 (Foxpark, Wyoming). The Cheyenne Astronomical Society hosts its seventh annual Weekend Under the Stars at a 9,100-foot site. Get information by calling Marty Curran, 3539 Luther Place, Cheyenne, WY 82001; phone, (307) 635-5944 (leave your mailing address); e-mail, mcurran@sisna. com; website, www.sisna.com/users/mcurran.

17 August 1–2 (Springfield, Vermont). The Springfield Telescope Makers have been hosting Stellafane since its inception in the 1930s. Telescope makers swap notes while others enjoy deep-sky observing. Write Stellafane, P.O. Box 50, Belmont, MA 02178 or visit their website, http://www.stellafane.com/.

18 August 2–9 (Valentine, Nebraska). The main impetus for the Prairie Astronomy Club's fourth annual Nebraska Star Party is deep-sky observing. Write Dave Scherping, 640 S. 30th St., Lincoln, NE 68510; phone, (402) 477-2596; e-mail, NSP@4w.com; website, http://www.4w.com/nsp/.

19 August 7–10 (Mt. Forest, Ontario). The North York Astronomical Association sponsors Starfest at a 200-acre campground 75 miles northwest of Toronto. For information write to Andreas Gada, 26 Chryessa Ave., Toronto, ON M6N 4T5, Canada; phone, (416) 761-1798; e-mail, tward@vision1.net.

20 August 8–9 (Virginia City, Montana). The Southwest Montana Astronomical Society's Starwatch boasts the darkest skies east of the Continental Divide. Write Mike Murray at the Museum of the Rockies, 600 W. Kagy Blvd., Bozeman, MT 59717; phone, (406) 994-6891; e-mail, ammmm@gemini.oscs.montana.edu; website, http://www.alpinet.net/~strategx/MT_Astro.html.

21 August 28–September 1 (Oregon). The Oregon Star Party meets 150 miles southeast of Portland in the Ochoco National Forest. Enjoy swap meets, guest speakers, vendor displays, and impromptu talks under the night sky. Write to the Oregon Star Party Committee, P.O. Box 91416, Portland, OR 97291 or call Chuck Dethloff at (503) 357-6163; e-mail, ospinc@teleport.com.

22 August 29–September 1 (Alma, New Brunswick). The Royal Astronomical Society of Canada's Halifax Centre presents Nova East '97 in Fundy National Park. Write Paul Gray at 49 1/2 Windmill Rd., Dartmouth, Nova Scotia Canada B3A 1C6, Canada; phone, (902) 469-0947; e-mail, pgray@hercules.stmarys.ca. The party's website is http://apwww.stmarys.ca/rasc/ne. ☐

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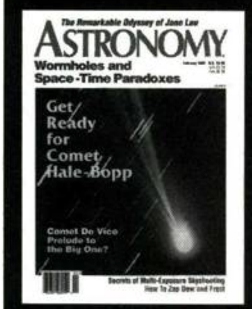
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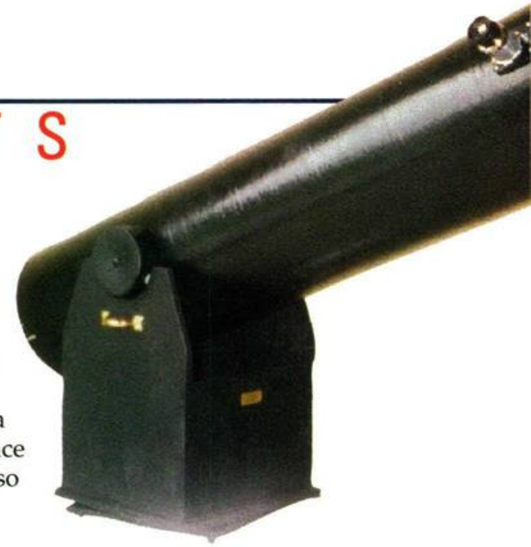

10-inch Dobsonian Telescope

North Star Telescopes introduces a 10-inch f/6 model to their line of Dobsonian telescopes. A black sonotube tube assembly contains a 10-inch mirror with optical quality guaranteed to ⅛-wave. The mirror sits on three points in a fully adjustable plywood cell, held in place by steel mirror-support clips. You can also collimate the tube's low-diffraction secondary mirror mount. A helical focuser adjusts over a three-inch range to accommodate a variety of 1¼-inch eyepiece designs. The telescope tube pivots inside a rocker box made from cabinet-quality plywood and painted flat black. All bearing surfaces ride on Teflon pads. The scope also comes with a 25mm multicoated eyepiece.

North Star Systems, P.O. Box 99, Ellenburg Depot, NY 12935; phone, (518) 594-7250. North Star 10-inch f/6 Dobsonian telescope: $459 plus $59 shipping. Visa, Mastercard, American Express, and personal check orders welcome. C.O.D. orders add $5. New York residents add 7% sales tax.

Clipboard Reference

Backyard observer Jim Hunter tired of going back and forth between his telescope and house for reference materials, so he created what he calls the Clipboard Buddy. Among other things, it has tips on how to polar align an equatorial mount and collimate a telescope's optics. Tables give information on the seasons, the constellations, 46 annual meteor showers, converting between time zones, 134 of the brightest deep-sky objects, and guide stars for calibrating a telescope's setting circles. Hunter also provides observing record sheets, drawing circles for eyepiece renderings, and space where you can jot down the addresses, phone numbers, and other contact information of other backyard astronomers. The sheets come with a binder and clipboard.

Clipboard Buddy For The Astronomer
Deep sky objects
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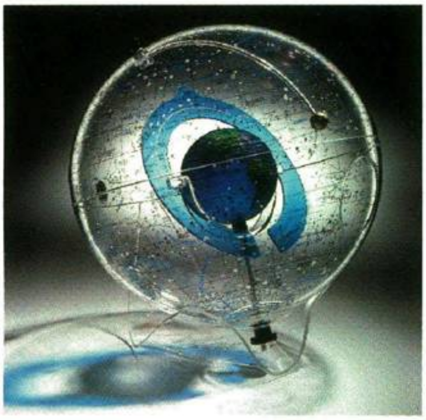
Record Sheets
Plus
Polar Alignment Guide

John Hunter/Newlife, 255 Reed St., Covina, CA 91723; phone, (818) 332-4913. The Clipboard Buddy: $29.95 plus shipping and handling.

Hubble Slide Set

What a View! is the fifth in a series of educational slide sets produced by the Astronomical Society of the Pacific that features the best images taken by NASA's Hubble Space Telescope. The 20-slide set includes famous pictures like the Eagle Nebula's dust pillars, the Deep Field image that revealed thousands of galaxies, a mosaic of the Orion Nebula, and recent images of the planets. An accompanying booklet contains detailed captions for each slide.

Astronomical Society of the Pacific, HST Slide Orders Department, 390 Ashton Avenue, San Francisco, CA 94412; phone, (415) 337-1100; fax, (415) 337-5205; toll-free (800) 335-2624. HST #5: *What a View!* slide set: $26.95 plus $5 shipping. Visa and Mastercard orders are welcome.



Transparent Celestial Globe

Starship Earth II suspends a model Earth within a 16-inch transparent acrylic globe that portrays the heavens. The celestial globe presents all 88 constellations and more then a thousand naked-eye stars imprinted with distance data. Plots also show many prominent deep-sky targets, keyed by object type against a right ascension and declination grid. Comet Hale-Bopp's path also appears through the sky. The Milky Way and Magellanic Clouds are shown in blue. A rotatable model Earth sits within an adjustable horizon ring and a movable sun ball to simulate the sky from anywhere on Earth. *Starship Earth II* sits on an acrylic base and comes with an owner's manual compiled by former ASTRONOMY contributing editor James Mullaney. It features data tables and simple astronomical exercises you can do with the globe.

Spherical Concepts, Inc., Department A, 12 Davis Avenue, Frazer, PA 19355; phone, (610) 296-4119; toll-free order line, (800) 220-5220. Starship Earth II Celestial Globe: $399 plus $22.95 shipping. Pennsylvania residents add 6% sales tax. Dealer inquiries welcome.

ASTRONOMY assumes no responsibility for the product information supplied by manufacturers. Prices are retail and subject to change without notice. Suppliers should send announcements and color photographs to the attention of John Shibley, P.O. Box 1612, Waukesha, WI 53187, or newprod@astronomy.com

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The Galaxy Catalog — http://www.astro.princeton.edu/~frei/galaxy_catalog.html

The Hubble Deep Field — http://oposite.stsci.edu/pubinfo/PR/96/01.html

NASA's National Space Science Data Center — http://nssdc.gsfc.nasa.gov/photo_gallery/photogallery-astro-galaxy.html

Origins: Recent Origins Science from HST — http://www.hq.nasa.gov/office/oss/origins/recent_origins_science.html

SkyView Virtual Observatory — http://skyview.gsfc.nasa.gov/skyview.html

The University of Alabama (different categories of images) — http://www.astr.ua.edu/choosepic.html

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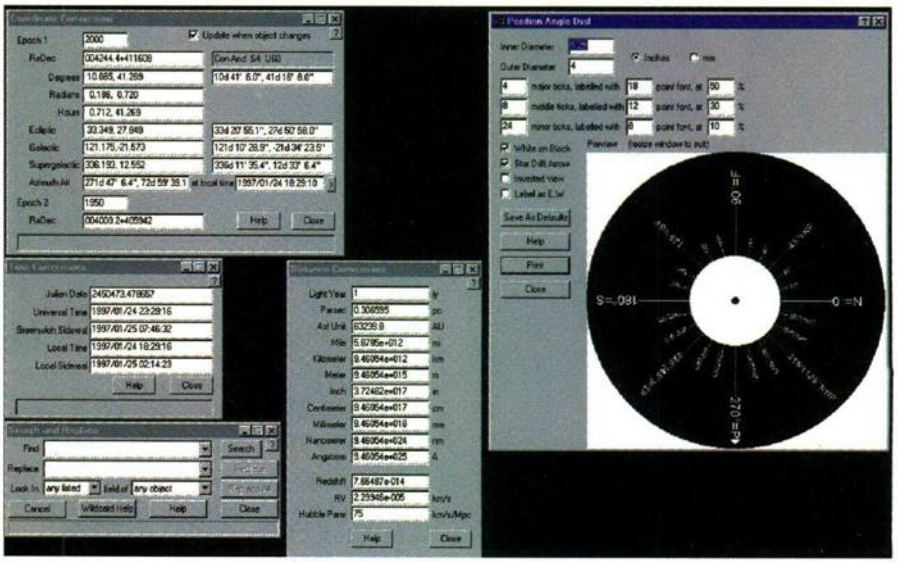
Hawaiian Astronomical Society Storybook and Deepsky Atlas

The Hawaiian Astronomical Society has undertaken mapping the entire sky and providing detailed maps, stories, and images of each constellation. Although not complete, enough of the Deepsky Atlas is available to be useful. Search the atlas online at http://www.iwe.com/has/deepsky.



Epoch 1 2000 ☑ Update when object changes
RaDec 004244.4+411608 Con And S4 UGD
Degrees 10.685, 41.269 10d 41' 6.0", 41d 16' 8.6"
Radians 0.186, 0.720
Hours 0.712, 41.269
Ecliptic 33.349, 27.849 33d 20' 56.1", 27d 50' 58.0"
Galactic 121.175,-21.573 121d 10' 28.9", -21d 34' 23.5"
Supergalactic 336.193, 12.552 336d 11' 35.4", 12d 33' 6.4"
Azimuth Alt 271d 47' 6.4", 72d 59' 38.1 at local time 1997/01/24 18:29:10
Epoch 2 1950
RaDec 004000.2+405942

Julian Date 2450473.478657
Universal Time 1997/01/24 23:29:16
Greenwich Sidereal 1997/01/25 07:46:32
Local Time 1997/01/24 18:29:16
Local Sidereal 1997/01/25 02:14:23

Find
Replace
Look In any listed field of any object

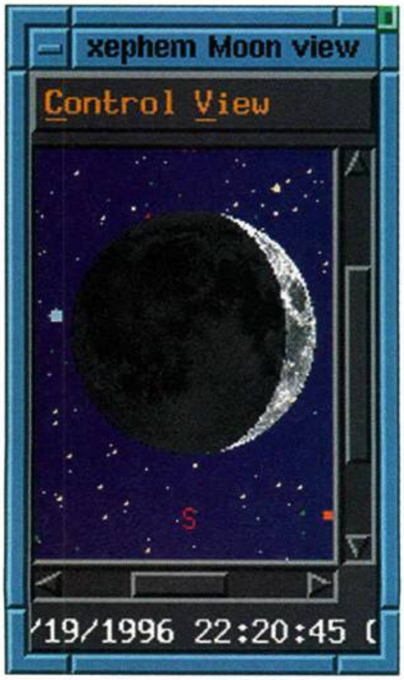
Light Year 1 ly
Parsec 0.306595 pc
Astr Unit 63239.8 AU
Mile 5.8786e+012 mi
Kilometer 9.46054e+012 km
Meter 9.46054e+015 m
Inch 3.72462e+017 in
Centimeter 9.46054e+017 cm
Millimeter 9.46054e+018 mm
Nanometer 9.46054e+024 nm
Angstrom 9.46054e+025 A
Redshift 7.66487e-014
RV 2.29946e-005 km/s
Hubble Param 75 km/s/Mpc

Inner Diameter
Outer Diameter 4 ● Inches ○ mm
4 major ticks, labelled with 18 point font, at 50 %
8 middle ticks, labelled with 12 point font, at 30 %
24 minor ticks, labelled with 8 point font, at 10 %
☑ White on Black
☑ Star Drift Arrow
☐ Inverted view
☐ Label as E,W

dObjects 2.1

Have you ever wanted to observe a deep-sky object but could only remember part of its name? *dObjects* for Windows 95 will remember the rest. Additionally, *dObjects* will give you volume and page numbers of references, pictures, and sketches of your elusive object from the Webb Society's Deep Sky Handbook, popular astronomy magazines, books, and Internet links. You'll get vital statistics, positions, and more in this database that includes data on more than 34,000 objects.

dObjects, 51054 Kingwood, Shelby Township, MI 48316-4524, (810) 731-4706, FAX: (810) 731-3143. E-mail: bondono@eaglequest.com. Website: http://www.eaglequest.com/~bondono/dObjects/dObjects.html. Price: $59.95 with complete database. Minimum requirements: Windows 95, 8 MB hard disk space available.



'19/1996 22:20:45 (

XEphem

XEphem is a free interactive astronomy program that runs on most popular versions of Unix using the X Windows system. Its database includes dozens of comets, thousands of asteroids, and allows users to create files describing additional solar system objects. It includes a sky map, a three-dimensional rotatable model of the solar system, and phases and features of the moon. It also portrays Galilean satellites, Saturn's rings and moons, and more. *XEphem* may be downloaded from its home page at http://iraf.noao.edu/~ecdowney/xephem.html.

XEphem comes with its own database of 3,286 stars, but supports use of the Positions and Proper Motions Catalog and the Hubble Guide Star Catalog, which may be obtained as a set of CD-ROMs from the Astronomical Society of the Pacific.

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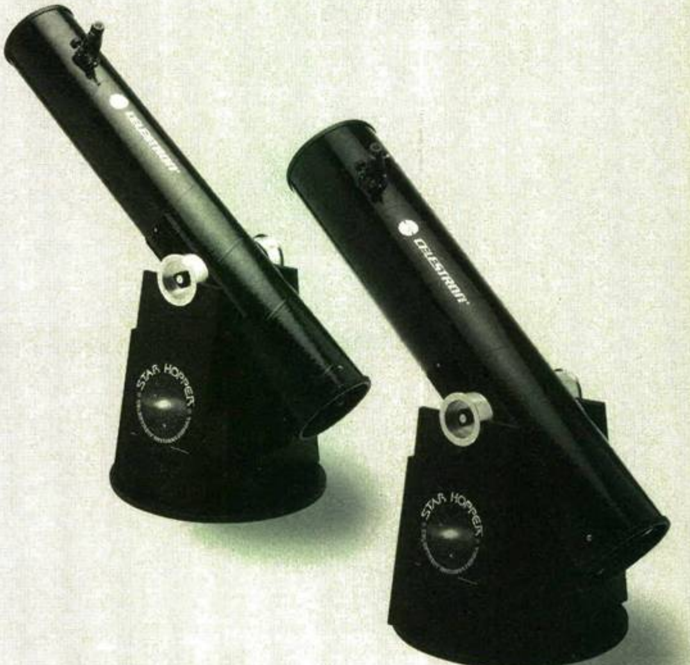

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- Manufactured at Celestron's factory in the U.S.A.
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Standard accessories include a 26mm multi-coated Plössl Eyepiece – 1¼" (35x), high quality 6x30 Finderscope and a 1¼" Focuser.

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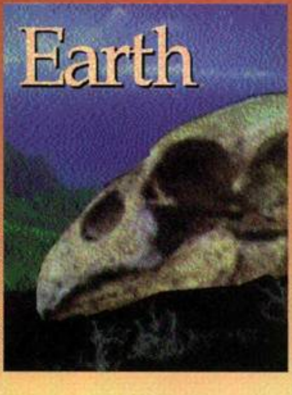

Visuals Unlimited; skull courtesy Smithsonian Institution

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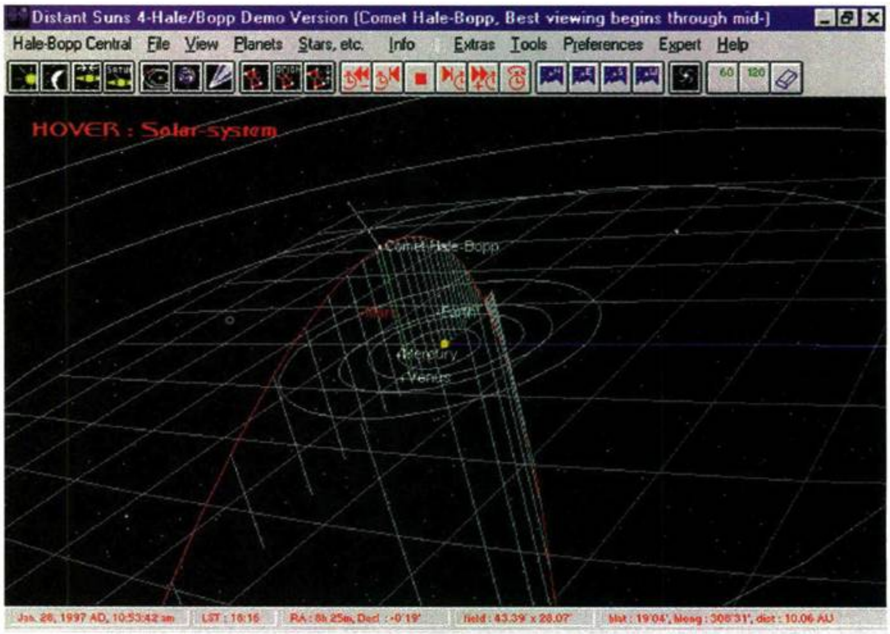
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Info
Extras
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120
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Mercury
Venus
Jan. 28, 1997 AD, 10:53:42 am
LST : 16:16
RA : 8h 25m, Decl : -0°19'
field : 43.39° x 28.07°
blat : 19°04', blong : 308°31', dist : 10.06 AU

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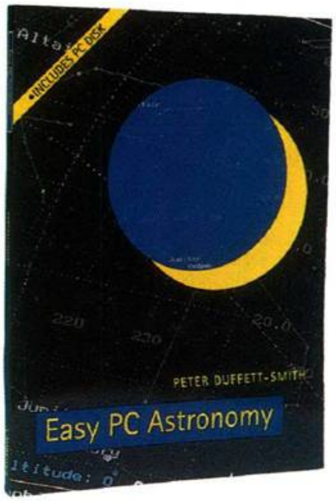
Easy PC Astronomy by Peter Duffett-Smith, is a book and diskette bundled together for users wishing to make astronomical calculations easily and accurately. The diskette provides a simple yet powerful script language called AstroScript with which a user can make complex calculations quickly. No expert knowledge of astronomy, math, or computer programming is required. *Easy PC Astronomy* is useful to amateur astronomers, high school or university students, science teachers, and research astronomers.

Easy PC Astronomy, Cambridge University Press, 40 West 20th Street, New York, NY 10011-4211. E-mail: pjds@mrao.cam.ac.uk. Price: $29.95. Minimum requirements: PC-compatible computer with DOS, 386 with coprocessor, 500 KB RAM and VGA screen.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Product information is as provided by the developer. Software developers may send new programs and upgrades to AstroBytes, ASTRONOMY, P.O. Box 1612, Waukesha, WI 53187-1612 or e-mail bytes@astronomy.com. Check out ASTRONOMY's home page at http://www.kalmbach.com/astro/astronomy.html

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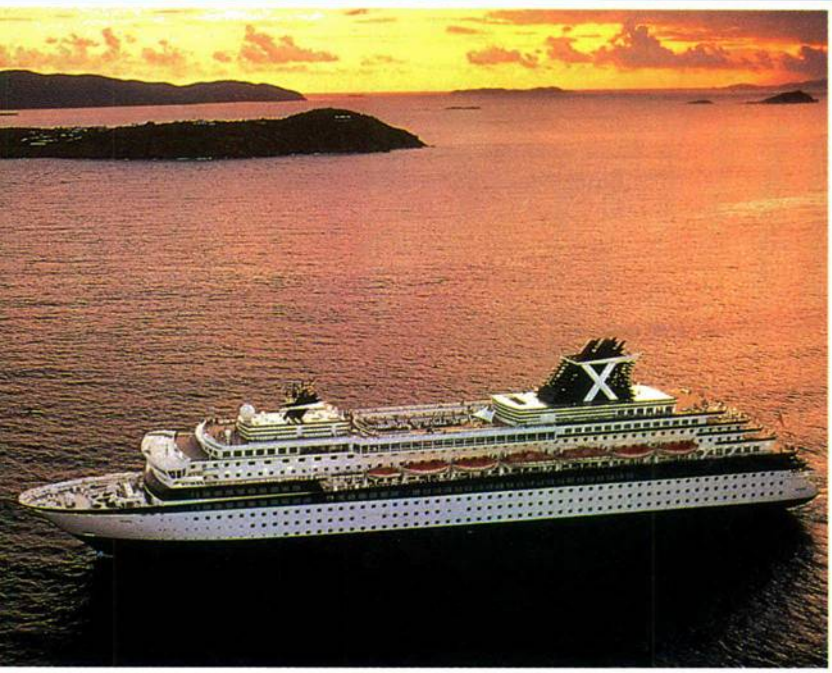

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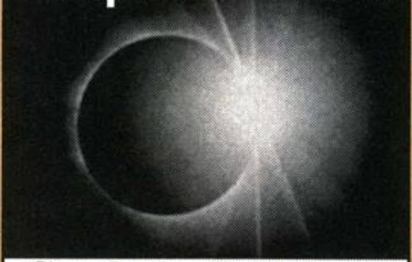

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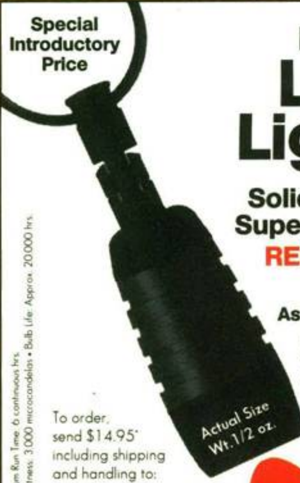

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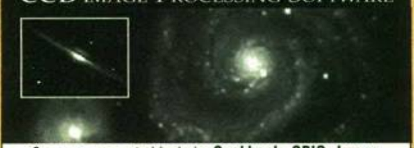

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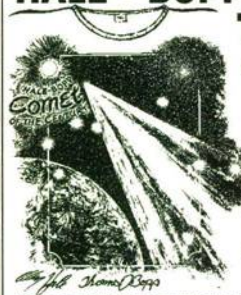

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David Harry Grinspoon, 340 pages, Addison-Wesley Publishing Company, New York, 1996; ISBN 0-201-40655-1, hardcover, $27.50

For centuries we have only been able to observe the top layers of the mysterious, cloud-enshrouded world next door: Venus. This fascinating book by University of Colorado planetary scientist David Grinspoon makes accessible to all the wealth of information that we have recently gathered from our space probes to Venus.

When I began reading *Venus Revealed* I wondered if I would be able to understand much of it, because Venus is not one of my main areas of astronomical interest. But I had no trouble at all, and neither will you. It reads like an absorbing novel. Grinspoon's style is friendly and conversational. I felt as if he was talking directly to me.

Grinspoon starts off by covering the futile attempts to understand Venus from observing only the top of the cloud cover. Previous theories were totally off the mark. One held that Venus was covered by a global swamp teaming with dinosaurs or other primitive creatures. Astrophysicist Fred Hoyle proposed in the 1950s that Venus was covered in oil.

The author spends a good deal of time on the Magellan spacecraft, which mapped virtually the entire surface in exquisite detail during the early 1990s — giving scientists a global perspective of Venus. I was fascinated by Grinspoon's coverage of the trials and tribulations of the project and his retelling of how the mission nearly failed due to a glitch in the spacecraft's computer code. The book contains many of Magellan's radar images, some clearly reproduced on a handful of glossy pages. Unfortunately, many additional images are too dark to be of much use. The numerous graphics helped clarify the concepts discussed in the text.

Grinspoon does a nice job comparing and contrasting the surfaces and atmospheres of Earth, Venus, and Mars. Of these three rocky planets, Earth is the oddball. Our planet's atmosphere lacks the high concentrations of carbon dioxide present in the atmospheres of Venus and Mars. The author explains how this and other factors contribute to the lack of surface water on Venus and Mars.

Grinspoon brings out another interesting fact. Our knowledge of how we are destroying Earth's ozone layer came about after atmospheric chemists discovered the lack of such a protective layer on Venus. Scientists found that chlorine and fluorine destroy ozone in Venus's cloud tops, so they suspected that the same chemical reactions could occur on Earth. These two inert chemicals are the main ingredients in the chlorofluorocarbons (CFCs) that we use in refrigeration systems. When these inert chemicals reach the upper atmosphere, they react with ozone and destroy it. Ozone protects us from the sun's deadly ultraviolet radiation; without the ozone layer we would soon perish from ultraviolet-induced cancers.

VENUS REVEALED
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The final portion of the book covers the various surface features on Venus and how scientists think they formed. Grinspoon also discusses the active tectonics and volcanism that shape Earth and Venus. Baffling are the mountain tops that shone brightly in the radar images. Are they covered with some kind of metallic layer? Scientists speculate that they might be covered with a thin layer of iron or even iron pyrite (fool's gold).

The discussion of Venus's greenhouse effect is lively and informative. Past and present volcanism has spewed massive amounts of lava and the greenhouse gases sulfur dioxide and water vapor into the atmosphere while at the same time reshaping the Venusian landscape.

Who is this book for? The author says that his book "is written not for planetary scientists but for everyone else." I certainly agree and highly recommend it to you, even if you have only a passing interest in Venus. After reading this book, the "mysterious" planet seems less mystifying. *Venus Revealed* has stimulated a new interest about this no longer so enigmatic world. — *Robert A. Garfinkle*

OTHER BOOKS

First Light: The Search for the Edge of the Universe

Richard Preston, 275 pages, Random House, New York, 1996; ISBN 0-679-44969-8, hardcover, $24.

Richard Preston, author of *The Hot Zone*, has revised and updated his 1987 book about the thrilling research done with the 200-inch telescope atop Palomar Mountain. The original version, which won the prestigious American Institute of Physics Science Writing Award, describes astronomers' attempts to understand the birth of the universe.

Astrology: What's Really in the Stars

J.V. Stewart, 156 pages, Prometheus Books, Amherst, N.Y., 1996; ISBN 1-57392-077-0, hardcover, $19.95.

This book traces the development of astrology from 4000 B.C. to the present. The author also discusses the contradiction of why this belief system, which is based on ancient

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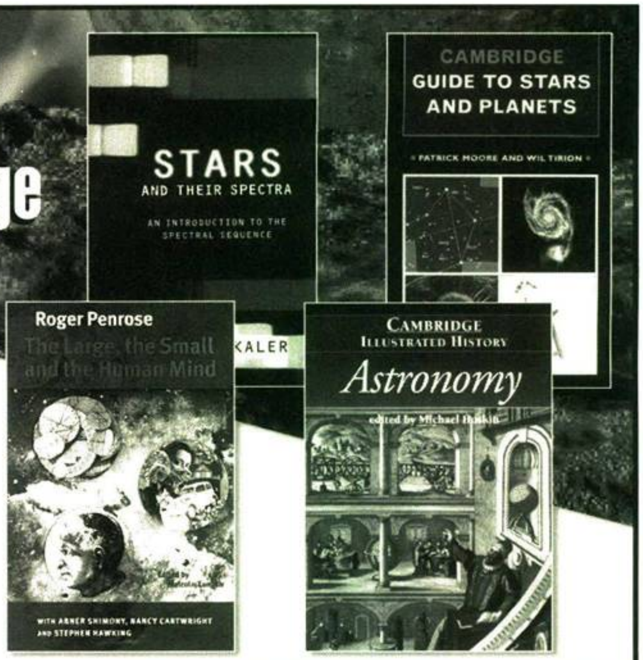
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Packed with anecdotes and intriguing detail, this book describes how we observed the sky and interpreted what we saw at different periods of history; how this influenced our beliefs and mythology; and how great astronomers contributed to what we now know.

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This comprehensive handbook contains charts of the stars in all 88 constellations of the night sky, as well as a concise overview of astronomy presented in nine short chapters. Each map has a clear explanation of the more interesting objects in the constellation depicted.

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The Large, the Small and the Human Mind

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Malcolm Longair, *Editor*

Roger Penrose's original and provocative ideas about the physics of the Universe, quantum physics and the physics of the mind have been the subject of controversy and discussion. In this book, he summarizes and brings up to date his current thinking in these complex areas. Abner Shimony, Nancy Cartwright and Stephen Hawking scrutinize these ideas and present their own distinctive positions.

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mythology, is so popular in this age of rapid scientific progress and space exploration. The book is a wonderful resource for those who enjoy debunking pseudoscientific nonsense.

History of Astronomy: An Encyclopedia

John Lankford, editor, 594 pages, Garland Publishing, New York, 1996; ISBN 0-8153-0322-X, hardcover, $95.

This encyclopedia brings together people, observatories, scientific topics, and much more in a comprehensive overview of the history of the oldest science. Subjects are arranged in alphabetical order for easy reference. Written for the layperson, it assumes no advanced knowledge of physics or mathematics.

Endeavour Views the Earth

Compiled by Robert A. Brown, 85 pages, Cambridge University Press, New York, 1996; ISBN 0-521-57099-9, paper, $11.95.

This small book gives you an inexpensive way to own some spectacular photos of Earth taken from the space shuttle. The 37 images were taken by shuttle astronauts during the STS-47 mission of Endeavour in September 1992. Each photo is accompanied by a short caption and a map.

The Scientific 100: A Ranking of the Most Influential Scientists, Past and Present

John Simmons, 504 pages, Citadel Press, Secaucus, N.J., 1996; ISBN 0-8065-1749-2, hardcover, $29.95.

Who are the greatest scientists of all time? Science writer John Simmons ranks the top 100 scientists in history, with short biographies that illuminate each person's contribution to the advancement of human knowledge. While the book covers many different fields of science, astronomers and physicists such as Copernicus, Kepler, Galileo, Newton, Einstein, and Hubble are prominent. While it's hard to quibble with Simmons's top choice, many ASTRONOMY readers would have ranked Edwin Hubble a little higher than 30th. But you'll enjoy comparing your rankings with the author's.

The Art and Science of CCD Astronomy

David Ratledge, editor, 176 pages, Springer-Verlag, New York, 1997; ISBN 3-540-76103-9, paper, $39.95.

Imagine taking pictures with the click of a mouse button. Amateur astronomers around the world image celestial objects with charge-coupled device (CCD) cameras and operate telescopes through computers. This revolutionary technology inspires many questions and 12 prominent amateur astronomers answer many of them in *The Art and Science of CCD Astronomy*. Tim Puckett, Gregory Terrance, David Ratledge, George Sallit and others explore techniques and solutions to many challenges that CCD imagers face. The book is loaded with charts and pictures, including a 16-page color gallery at the back. This is the fifth installment of Springer-Verlag's Practical Astronomy series.

Cambridge Illustrated History of Astronomy

Michael Hoskin, editor, 392 pages, Cambridge University Press, New York, 1997; ISBN 0-521-41158-0, hardcover, $39.95.

This volume can serve as an invaluable reference tool for those interested in the development of astronomy as a science and in how the changing view of the universe impacted society at large. The book is arranged chronologically, with individual chapters devoted to subjects such as astronomy in antiquity, Islamic astronomy, Newtonianism, and the rise of astrophysics. Small boxes with interesting anecdotes appear throughout the book. For example, on page 236, the reader learns that British astronomer John Michell first proposed the idea of a black hole way back in 1784. A chronology at the end of the book highlights some of astronomy's most critical discoveries. The writing is accessible and the book contains many photographs and illustations. □

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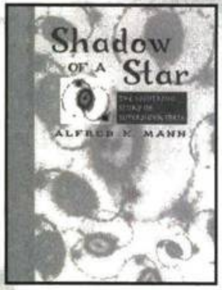

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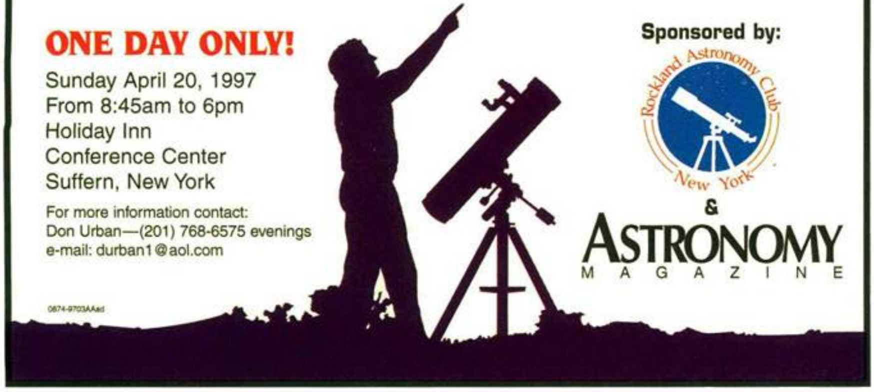

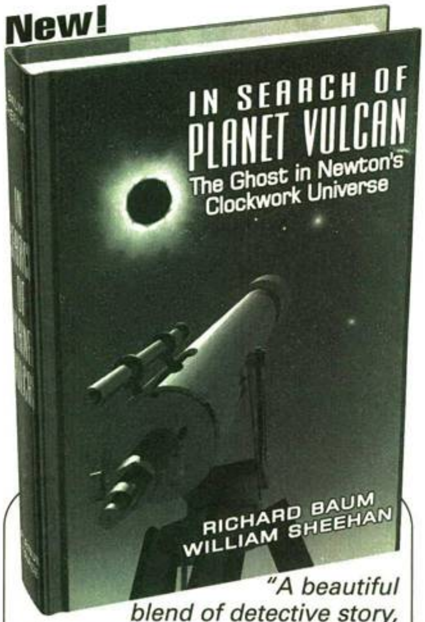
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ASTRONOMY back issues. October 1974 through July 1978, complete. $125.00. (909) 672–2267.

ASTRONOMY Sept. 1989- present. SKY & TELESCOPE 1946/ 1983. $1.50 each. Ralph Nafziger, PO Box 1476, Albany, OR 97321.

NATIONWIDE TELESCOPE TRADER. Free classified ad with subscription (6 issues) $20: POB 659, Carmichael, CA 95609-0659. (916) 483–6381.

Books and Periodicals Wanted

$10 reward for the June issue of ASTRONOMY of 1978. Write Dean Lucas, 2095 Graybar Lane, Nashville, TN 37215.

Your antique telescope photo/history published in first book of antique telescopes. N.S.A.S., e-mail N46STAR@AOL.COM phone/fax (612) 937–6087.

Miscellaneous For Sale

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New theory on the origin of the moon. Explains everything. http://www.spa.net/~mwright

Telescopes For Sale

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Crayford focusers 1.25" $39.00, 2.00" $59.00. Call Mike Fallwell (909) 486–9116.

Mead 2120 10" SCT LX-5 2" eyepiece holder, diagonal, 4 eyepieces, filters. $1,000. Skip Wall, San Jose, CA (408) 279–8681.

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MEETINGS
EVENTS

Riverside Telescope Makers Conference in California's picturesque San Bernardino Mountains is the place to be Memorial Day Weekend. One of the most popular star parties of the year, it offers a first-hand look at the latest in telescope making. Here you can compare the tools and techniques available to you and realize your full potential for astrophotography and deep-sky and planetary observing. A veritable Who's Who in astronomy, attendees include editor Bonnie Gordon, managing editor Dave Eicher, and other ASTRONOMY *contributors. Riverside is the spark to start your summer observing.*

May 1-4
Peach State Star Gaze, Indian Springs State Park near Jackson, Georgia. Sponsored by the Atlanta Astronomy Club. Contact Ken Poshedly, 3440 Everson Bay Court, Snellville, GA 30278, (770) 979-9842, ken.poshedly@mci2000.com.

May 2-4
Third Annual Delmarva Star Gaze, Tuckahoe State Park, Queen Anne, Maryland. Contact Lyle Jones, 230 N. Bradford Street, Dover, DE 19901, (302) 736-9842, www.udel.edu/dmiller/gazers.html.

May 3
Tenth Annual STARCONN Convention, Wesleyan University, Middletown, Connecticut. Sponsored by the Astronomical Society of Greater Hartford. Contact Scott Tracey, 154 Mountain Road, North Granby, CT 06060, (860) 653-0179.

May 4-11
Texas Star Party, new location in the Texas Hill Country, Alto Frio Baptist Encampment, near Rio Frio, Texas. Advance reservations, (713) 721-6488. Contact TSP Registrar, 1326 Mistywood, Allen, TX 75002, KASTRO@aol.com, or Website http://www.metronet.com/~tsp/.

May 4-11
WesTex: West Texas Star Party, Prude Ranch, Fort Davis, Texas. Contact (915) 426-3201.

May 7
Astronomy Workshop, Washburn University campus, Topeka, Kansas. Contact Brenda Culbertson, 511 S.W. Buchanan #2, Topeka, KS 66606-1169, or e-mail (Attn: Brenda Culbertson c/o D. Parnell) zzparn@acc.wuacc.edu.

May 7-10
Middle Atlantic Planetarium Society Annual Meeting, Wilmington, Delaware. Contact Laura Deines, Southworth Planetarium, P. O. Box 9300, Portland, ME 04104-9300.

May 7-11
Advanced Adult Astronomy Camp, Mt. Lemmon and Bigelow Observatories, University of Arizona, Tucson, Arizona. Contact (520) 621-7079, dmccarthy@as.arizona.edu.

May 10
Moore Relic Show, Belton, Texas. Meteorite tektites, fossils. Contact Moore Relic Show, P. O. Box 247, Salado, TX 76571, (817) 778-2206.

May 22-24
IAPPP Big Bear Symposium, San Bernardino, California. Sponsored by International Amateur-Professional Photoelectric Photometry. Contact Lee Snyder, P. O. Box 3964, Incline Village, NV 89450, (702) 831-1931.

May 24
Free Star Party, Ralph Worley Observatory, Hwy. 175, Shreveport, Louisiana. Contact Cran Lucas, (318) 797-1524, clucas@softdisk.com.

May 24-26
Riverside Telescope Makers Conference, Camp Oakes in the San Bernardino Mountains, east of Big Bear, California. Contact c/o Fox & Stephen, CPAs, 9045 Haven Avenue, Suite 109, Rancho Cucamonga, CA 91730, (909) 948-2205.

May 26-31
Spring Meeting of the American Association of Variable Star Observers, Sion and St. Luc, Switzerland. Contact AAVSO, 25 Birch Street, Cambridge, MA 02138-1205, (617) 354-0484, fax: (617) 354-0665.

May 31
Northeast Region Astronomical League (NERAL) Convention, Schenectady, New York. Contact Ron Baker, (518) 785-7423 (eve.), rbaker6633@aol.com. □

Please submit club announcements four months in advance to Meetings and Events, ASTRONOMY, *P. O. Box 1612, Waukesha, WI 53187-1612, or to tconley@astronomy.com.*

RESOURCES
PHOTOFACTS

At the Heart of the Lagoon (page 50)

"Plunge into the Lagoon," by David J. Eicher, ASTRONOMY, July 1996. A three-dimensional tour of the giant star factory.

A Film for all Nebula (page 82)

Star Ware, by Philip S. Harrington, (John Wiley & Sons, 1994). Lays out what's available on the market in the way of telescopes and accessories.

Birth of a Skyshooter (page 94)

Astrophotography for the Amateur, by Michael Covington, (Cambridge University Press, 1991). Good introduction to astrophotography tools and techniques.

---

p. 20: Brent Archinal, 50mm lens at f/1.4, Kodachrome 200 film, 10 seconds, 7/8/95; **p. 66:** Riverside Telescope Makers' Conference, May 1993, Alan Dyer, 35mm f/2 lens, Fuji 800 G film, 30 seconds; **p. 71,** Perseid meteor, Rick Schmidt, 50mm f/2.8 lens, Kodak Ektachrome 200, 15 minutes; **p. 72:** Occultation of Saturn by the moon, 10-inch f/5 reflector working at f/90 with a 7mm eyepiece, Kodak Ektachrome 400, 2 seconds, 12/29/83; **p. 73:** NGC 3242, the Ghost of Jupiter, Ronald Royer, 18-inch f/5 reflector, Fujichrome 1600D, 17 minutes; **p. 75:** Venus in March 1977, William Duffy, Jr., 50mm f/1.8 lens, Kodak Ektachrome 200 pushed to ISO 400, 1/5-second exposure; **p. 95, bottom left:** M104, the Sombrero Galaxy in Virgo, David Ponzer, 11-inch f/10 Schmidt-Cassegrain reflector, hypered Tech Pan 2415 film, 90 minutes; **bottom center:** M74 in Pisces, David Ponzer, 11-inch f/10 Schmidt-Cassegrain reflector, hypered Tech Pan 2415 film, 150 minutes; **bottom right:** NGC 1300 in Eridanus, David Ponzer, 11-inch f/10 Schmidt-Cassegrain reflector, hypered Tech Pan 2415 film, 150 minutes; **p. 96:** M51, the Whirlpool Galaxy in Canes Venatici, David Ponzer, 11-inch f/10 Schmidt-Cassegrain reflector, hypered Tech Pan 2415 film, composite of 60- and 90-minute exposures; **p. 97, top left:** NGC 1365 in Fornax, David Ponzer, 11-inch f/10 Schmidt-Cassegrain reflector, hypered Tech Pan 2415 film, 150 minutes; **top right:** NGC 253 in Sculptor, David Ponzer, 11-inch f/10 Schmidt-Cassegrain reflector, hypered Tech Pan 2415 film, 60 minutes.

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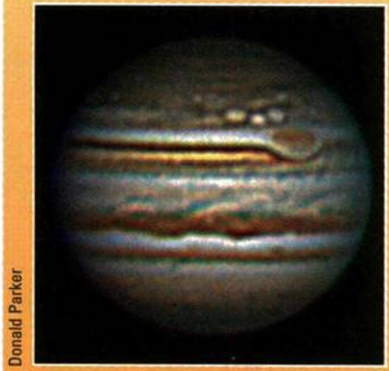
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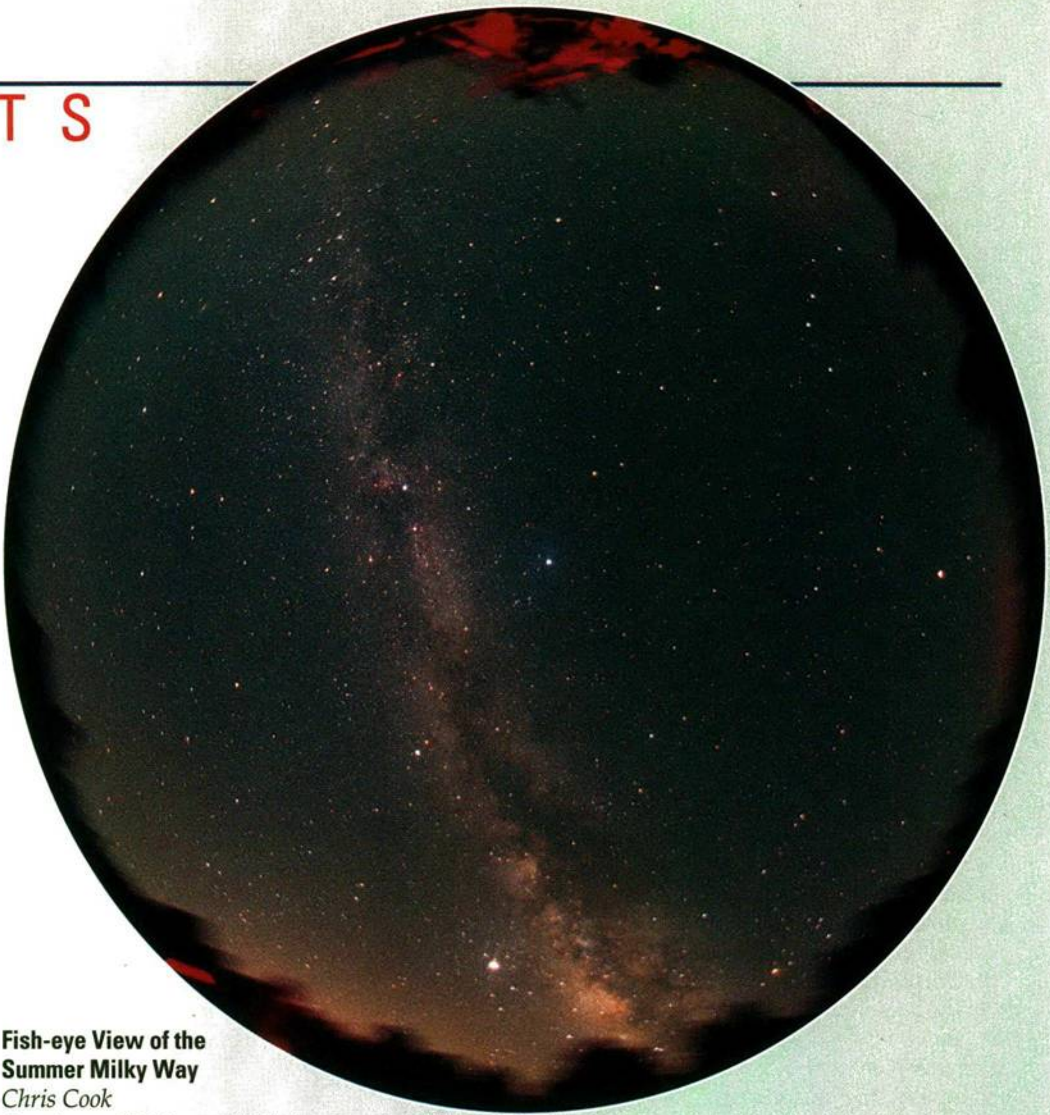
Twilight fades into a sky splashed with stars. The scope's set up and charts are carefully arranged on a nearby table. What wonders await as the night unfolds? Suddenly there's a sound . . . a rustle in the bushes, the crack of a branch.

Who goes there?

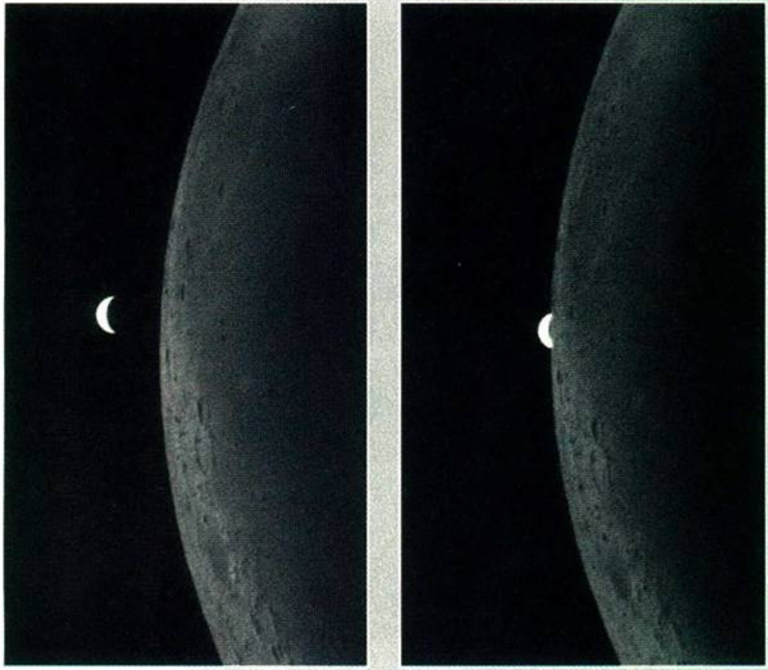
It may not happen on your first night out, but happen it will. Sooner or later you'll bump into something else that claims the night. Al Ebeltoft didn't have to journey very far to find this out. He was out in his Bigfork, Montana backyard last year doing astrophotography when suddenly floodlights on his house lit up. The spots only come on when something trips a motion sensor.

"At first I was upset at my wife for invading my sanctuary," Ebeltoft recalls. "But then the silhouette of this large black bear moved into view." After a momentary staredown with the would-be astrophotographer, the bear ambled down Ebeltoft's driveway and left. This was the first of many visits to come. "These days I carry a 24-inch flashlight," says Ebeltoft. "It makes for a good club . . . I hope!"

New York astronomer George Normandin takes a less defensive posture when it comes to the bruins in his nightlife. "I've had this 'Ursa Garbagecanus Destructus' problem a number of times while



Fish-eye View of the Summer Milky Way
Chris Cook
(8mm lens at f/2.8, hypered Fujicolor 800 film, 20-minute exposure)



The Moon Covers Venus
Jean Dragesco
(6-inch f/20 Maksutov telescope, Tech Pan 2415 film, 1/4-second exposure through a Wratten 29 filter, taken on July 12, 1996)

observing from my camp in the Adirondacks," he says. "At first I was scared, but then I realized that my telescope was not nearly as interesting to a bear as a neighbor's garbage can."

Aside from bears and an occasional coyote, observers in California must keep an eye open for other, more unusual night visitors: wild pigs. "It's a bit unnerving to hear a low snort from behind while looking through the eyepiece," says Bay-area skywatcher Mark Wagner. He often stumbles upon whole families of feral swine, ranging from, as he puts it, babies to very large moms and dads. "But, typically, the piggies and I have different night interests, and it remains a peaceable kingdom," he says.

San Jose observer David Smith was afflicted by more nefarious denizens of the night while observing near Mt. Hamilton. "Some shadowy figures moving around in a nearby field revealed themselves in my binoculars to be wild pigs," says Smith. "But the coyotes were spookier — they were howling from all directions."

Suddenly the yips and yowls were interrupted by several gunshots from the direction of a nearby highway. Perhaps a rancher, Smith thought, had had enough of the coyotes. But then a voice carried from a distant megaphone: "Police — come out with your hands up!" followed in short order by "All right, is that all of you?" Evidently Smith was privy to a bust, gunplay and all.

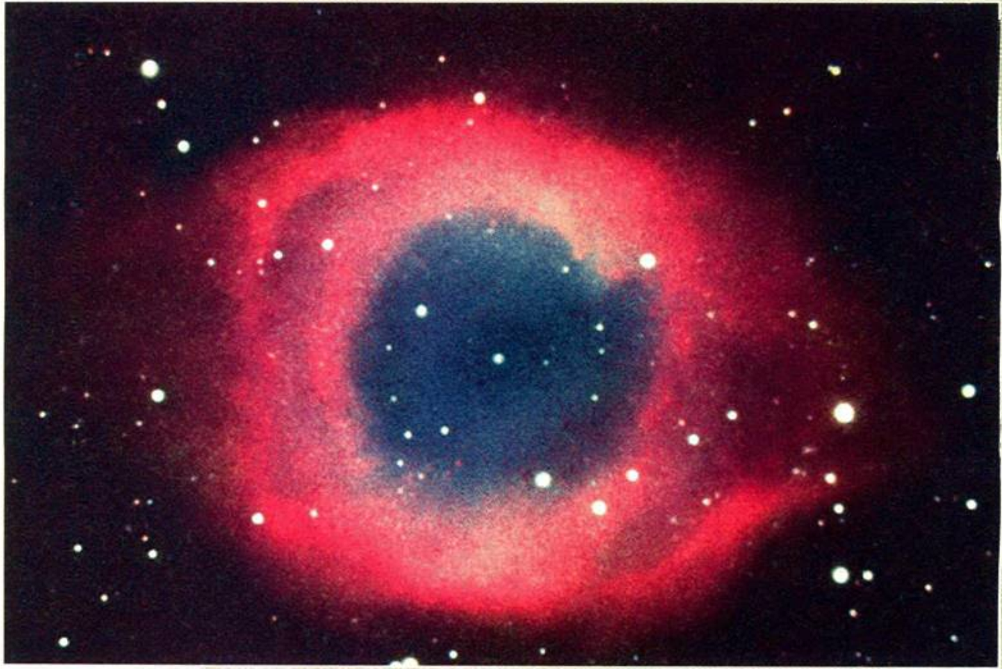
"My big mistake was relating this story to my wife the next day," Smith admits. "She put her foot down and wouldn't let me go out alone after that."

While insect night life may not be nearly as dangerous, it is often more

Orion and Taurus Rise over the Anza-Borrego Desert, California

Jerry Schad

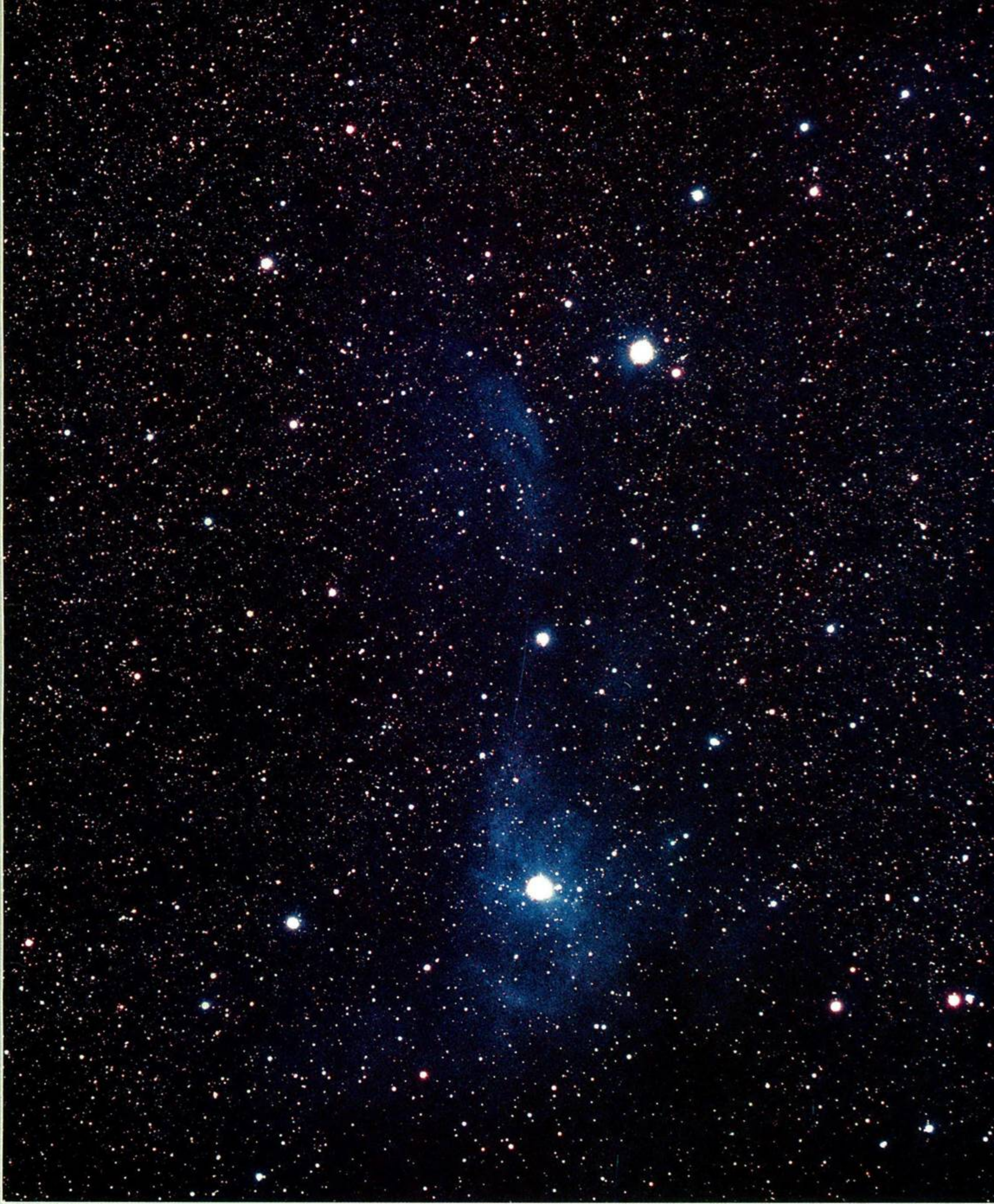
(24mm lens at f/1.4, Kodak Ektachrome P1600 film pushed to ISO 3200, 40-second exposure with foreground illuminated by flashlight)



The Helix Nebula in Aquarius (NGC 7293)

James R. Foster

(Digital composite of six exposures taken through a 14-inch Schmidt-Cassegrain telescope: Two on hypered Fuji HG400 film for 190 minutes and 110 minutes at f/6.3. Two on hypered Tech Pan 2415 film for 150 minutes (green filter) at f/6.3, and 265 minutes [light-blue 80b filter] at f/11. The last two exposures were 85 and 60 minutes on hypered Kodak PPF film at f/11.)



Van den Bergh 14/15 in Camelopardalis
George Greaney
(6-inch f/7 refractor, hypered Fuji SHG400 film, composite of two 60-minute exposures)

startling, as Sandy McNamara discovered one night 20 miles from an Illinois nuclear power station. "I was quietly observing when a bright yellow light filled the field of my eyepiece," McNamara recalls. She immediately scanned the horizon for traces of a possible explosion.

Not seeing anything, she returned to her telescope, heart still racing, only to discover a lightning bug crawling across her Schmidt-Cassegrain telescope's corrector plate. "He was gazing amorously at his reflection in the mirror below," she mentions.

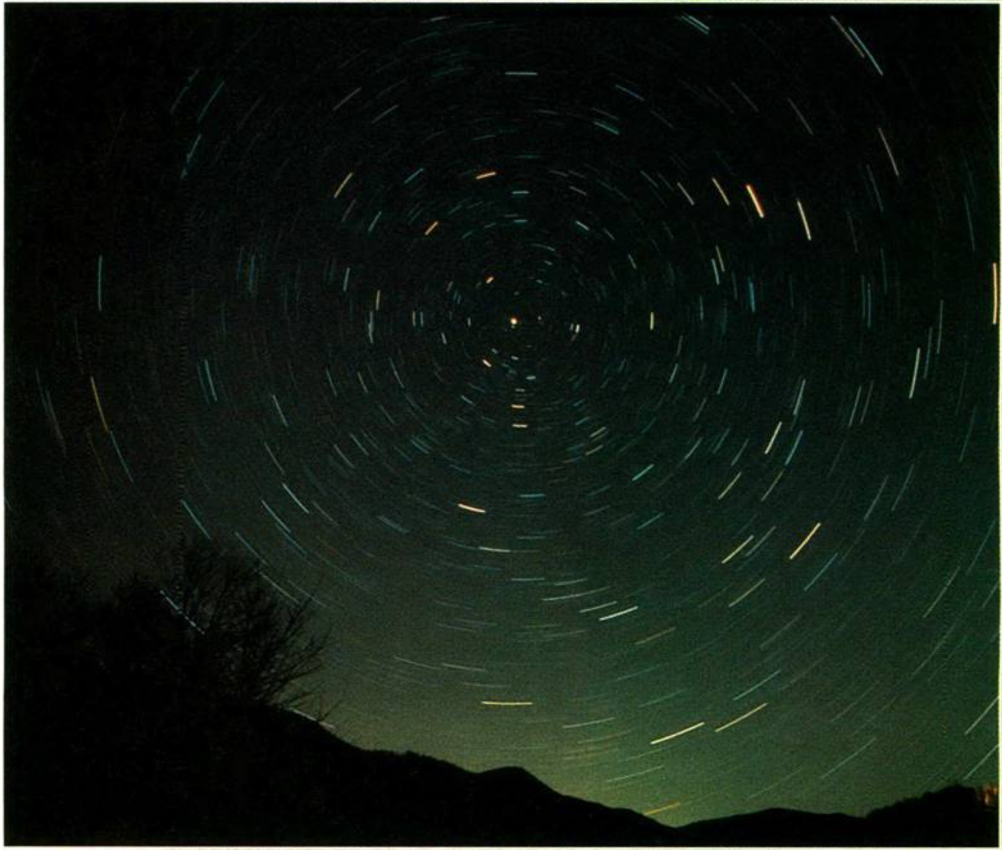
Mirrors attract still other creatures. Australian Eddie Trimarchi was testing out a newly installed electric drive on his Dobsonian telescope one clear night. His scope had to be perfectly balanced for the system to work properly. For the better part of 45 minutes, Trimarchi applied weight after counterweight to the front of his telescope tube, which seemed horribly out of balance.

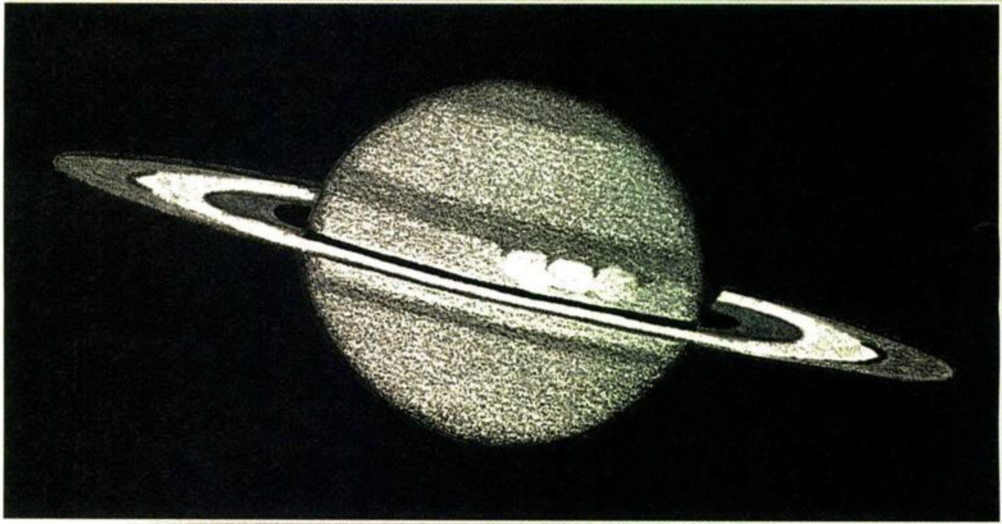
"Finally I gave up and lowered the tube, only to have my cat jump out," says Trimarchi. He mentions that this was marginally worse than the time he found her dancing around the primary mirror, chasing her reflection, after he had placed the optic down on the floor for a moment.

"Luckily," he recalls, "she didn't have her claws out." □

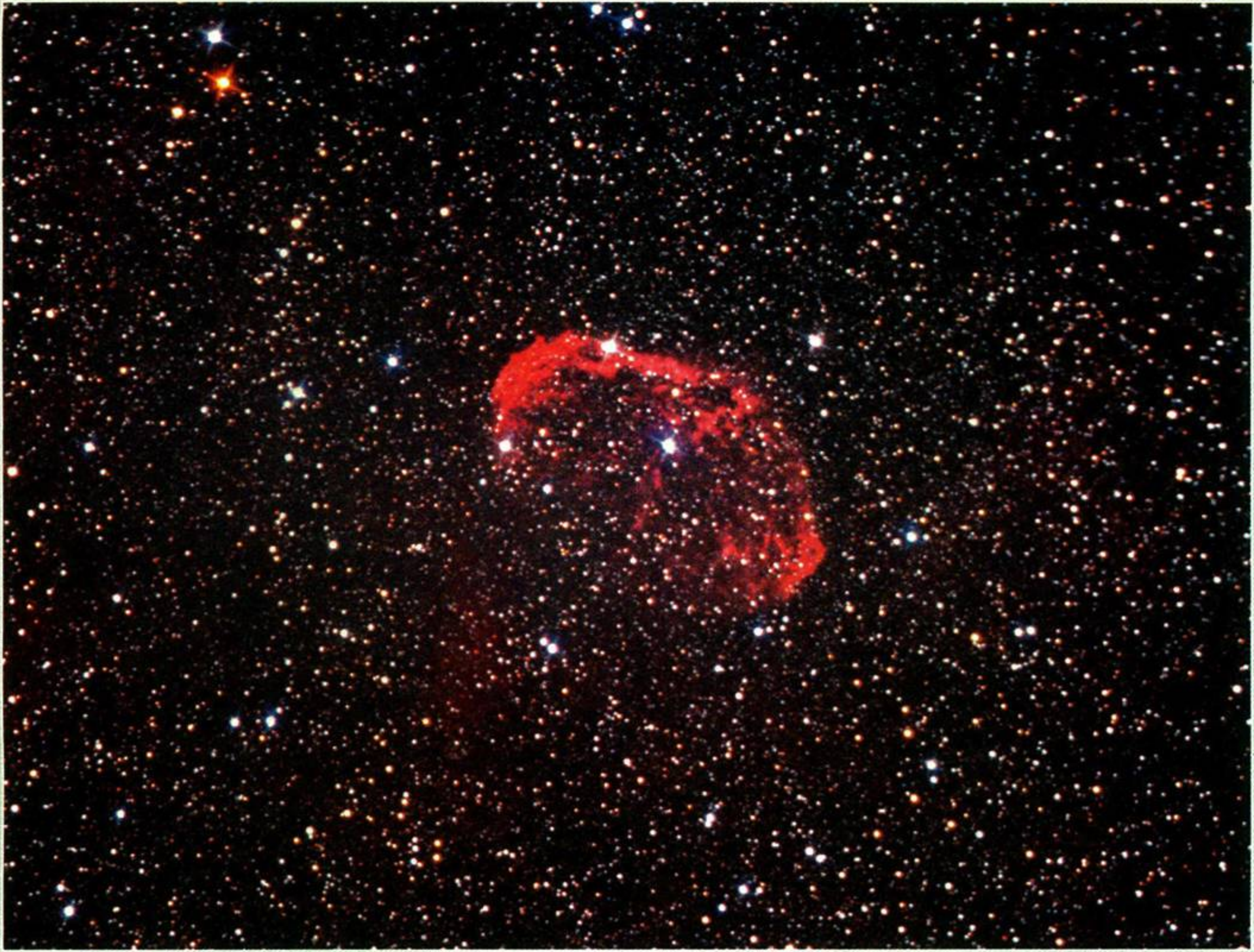
ASTRONOMY wants to share your adventures under the stars. Send submissions to John Shibley, Reader Reports Editor, ASTRONOMY, P.O. Box 1612, Waukesha, WI 53187-1612. Label each photo with photo data, name, address, and social security number. Send written reports and images via the Internet to: rreports@astronomy.com.

Star Trails around Polaris
Tim Barnwell
(28mm lens at f/4, Ektachrome 400 film, 7-minute exposure, foreground added by duping onto Kodak 5072 film)

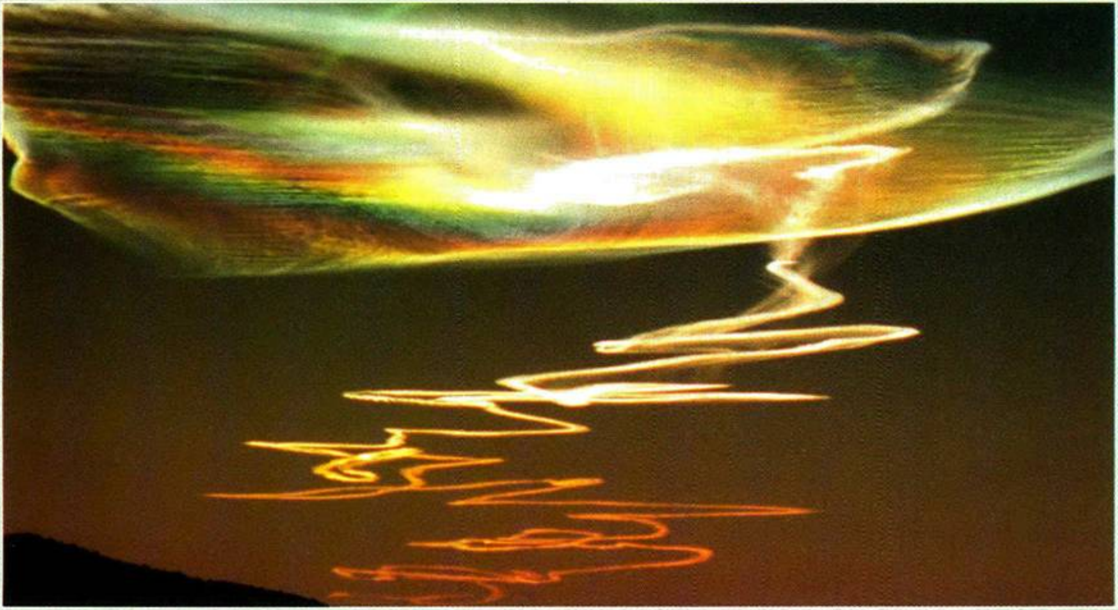




Saturn on December 10, 1996
sketch by David Weldrake
(12-inch f/5.3 Newtonian telescope at 350x)

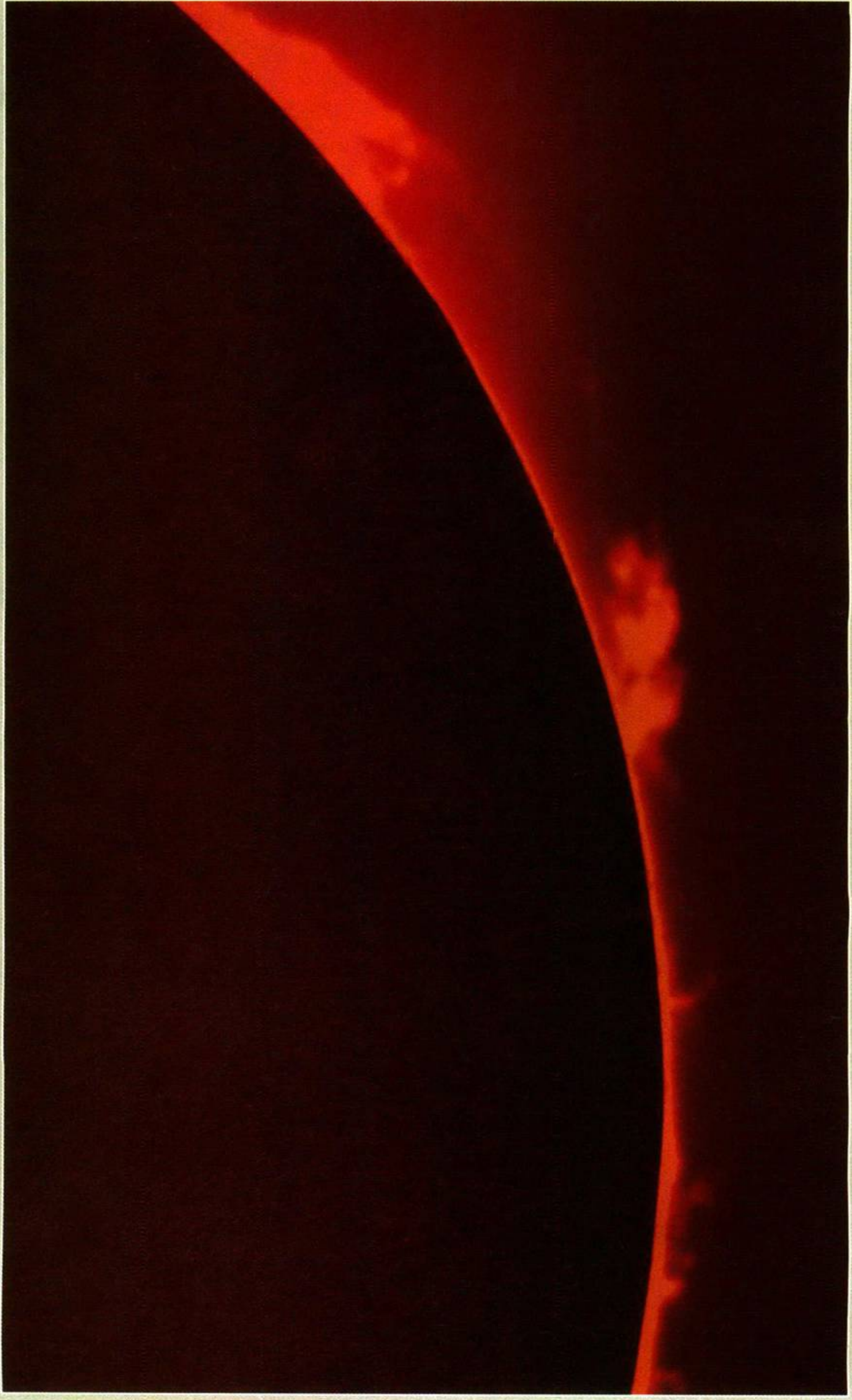


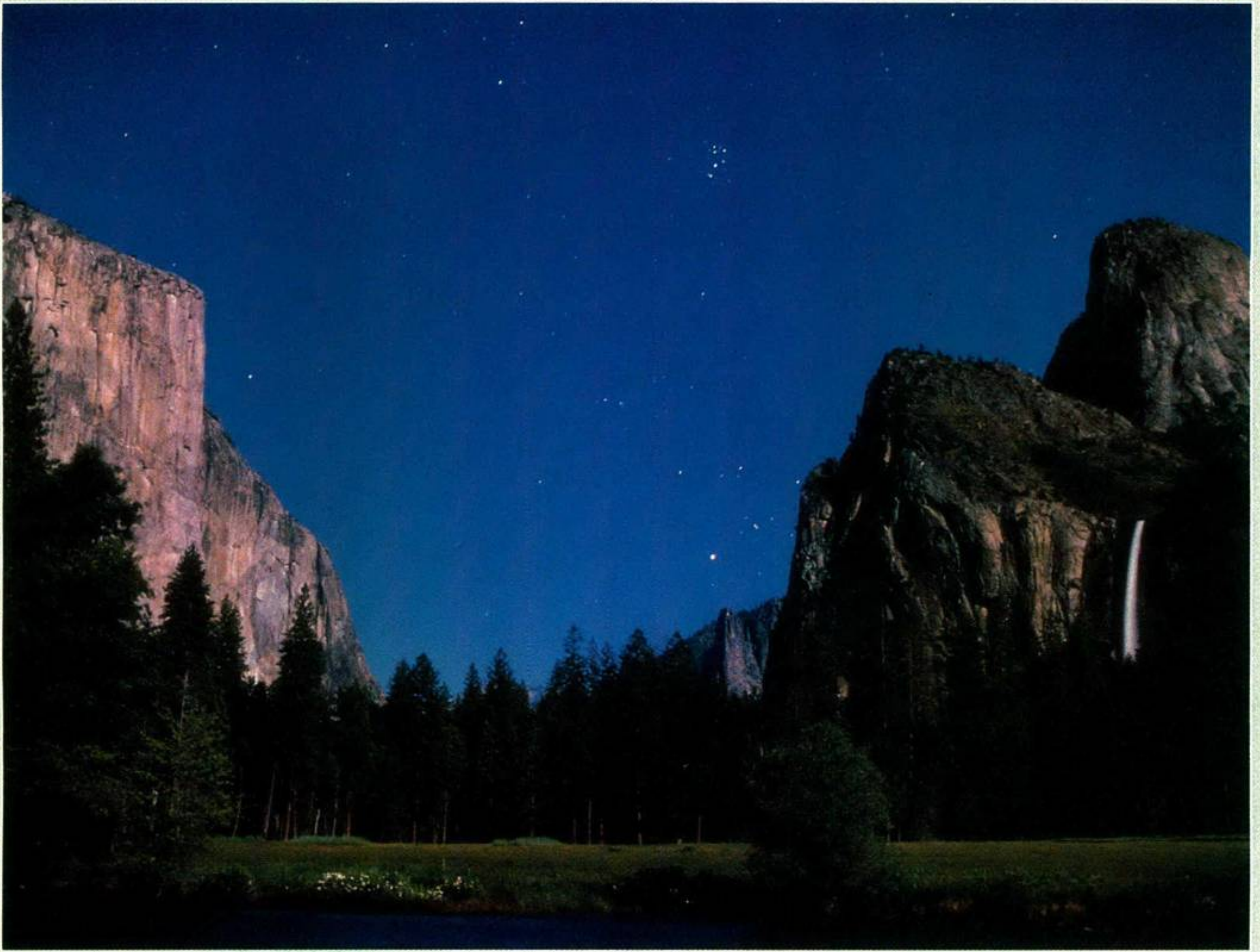
The Crescent Nebula in Cygnus (NGC 6888)
Chris Schur
(12.5-inch f/5 Newtonian telescope, hypered Kodak Pro 400 PPF film, 90-minute exposure)

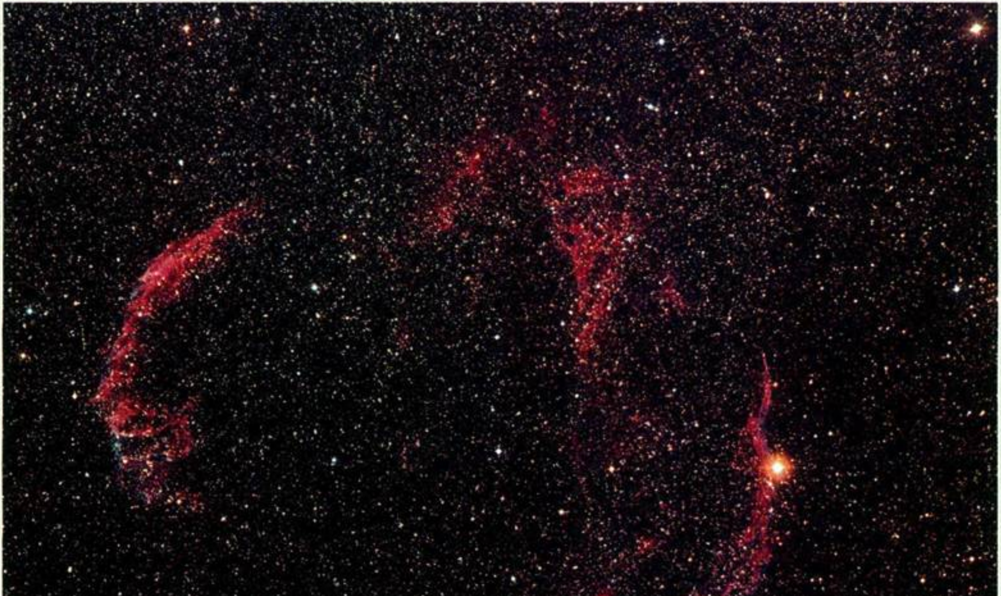


Rocket Launch from White Sands, New Mexico
David A. Fabrizio
(180mm lens at f/4, Kodak Pro 400 film, 1/60-second exposure, taken on October 9, 1996)

Solar Prominences
H. J. P. Arnold
(7-inch f/9 refractor with a 2x Barlow lens, Kodak Tech Pan 2415, ¼-second exposure through a DayStar 0.6-Angstrom H-α filter, taken on October 2, 1996)







The Pleiades (M45) over El Capitán
Frank Zullo
(35mm lens at f/2, Fujichrome Provia 100 film pushed to ISO 400, 20-second exposure)

The Veil Nebula in Cygnus (NGC 6960, NGC 6992-5)
Bill and Sally Fletcher
(8-inch f/1.5 Schmidt camera, hypered Tech Pan 2415 film, composite of a 16-minute exposure through a red filter, a 60-minute exposure through a green filter, and a 65-minute exposure through a blue filter.)

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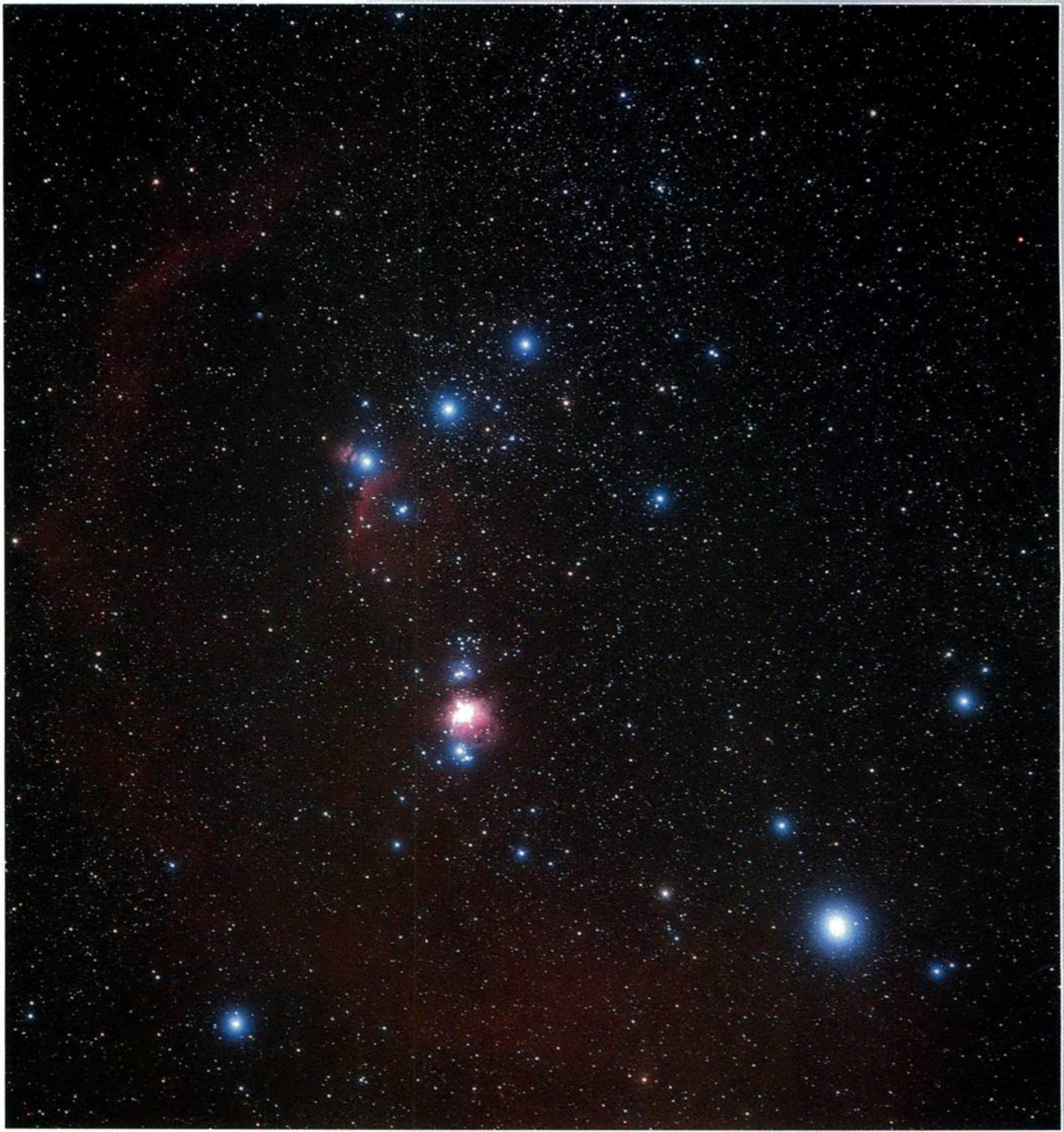

Lower Region of Orion the Hunter
Ron Luxemburg
(200mm lens at f/4.5, Kodak Pro 1000 PMZ film, 12-minute exposure)

Almost everything you see in this picture is part of a huge interstellar gas and dust complex called the Orion Association, which includes the bright stars of Orion. Astronomers suspect this and a host of other stellar associations formed 70 million years ago when a supernova sent shock waves throughout this region of the galaxy. The Orion Association lies between 900 and 1,200 light-years from Earth.

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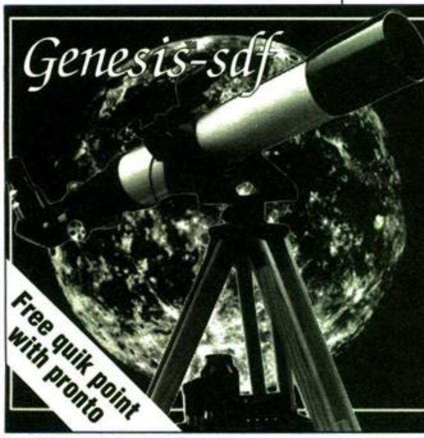

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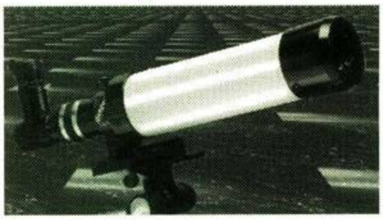

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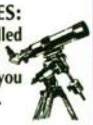

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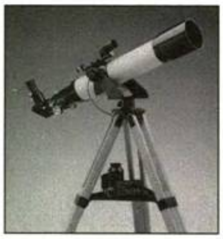

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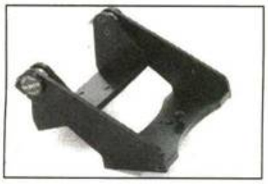

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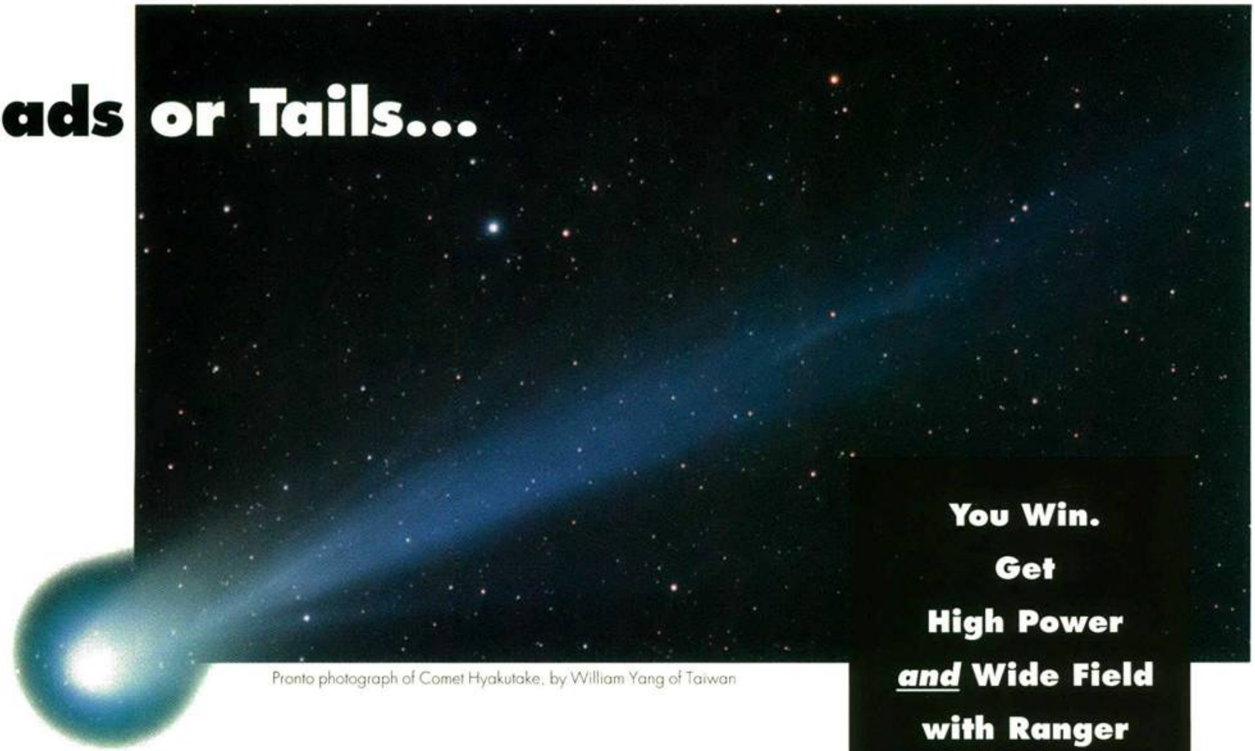

Pronto photograph of Comet Hyakutake, by William Yang of Taiwan

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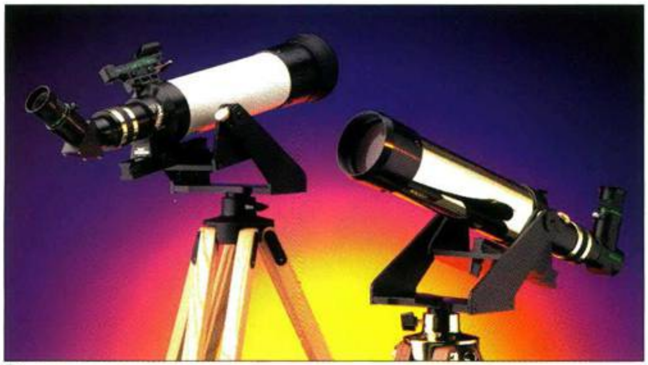

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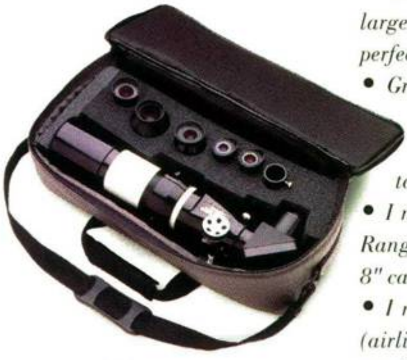

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